# SYLLABUS

## 1. Data about the program of study

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| 1.1 Institution | Technical University of Cluj-Napoca |
| 1.2 Faculty | Faculty of Automation and Computer Science |
| 1.3 Department | Computer Science |
| 1.4 Field of study | Computer Science and Information Technology |
| 1.5 Cycle of study | Bachelor of Science |
| 1.6 Program of study / Qualification | Computer science / Engineer |
| 1.7 Form of education | Full time |
| 1.8 Subject code | 3.00 |

## 2. Data about the subject

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|---|---|---|---|---|---|---|
| 2.1 Subject name | ***Special Mathematics I*** | | | | | |
| 2.2 Course responsible / lecturer | Prof. dr. Daniela Roșca - Daniela.Rosca@math.utcluj.ro | | | | | |
| 2.3 Teachers in charge of seminars / laboratory / project | Prof. dr. Daniela Roșca - Daniela.Rosca@math.utcluj.ro | | | | | |
| 2.4 Year of study | I | 2.5 Semester | 1 | 2.6 Type of assessment (E - exam, C - colloquium, V - verification) | | E |
| 2.7 Subject category | *DF – fundamentală, DD – în domeniu, DS – de specialitate, DC – complementară* | | | | | DF |
| | *DI – Impusă, DOp – opțională, DFac – facultativă* | | | | | DI |

## 3. Estimated total time

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|---|---|---|---|---|---|---|---|---|---|---|
| 3.1 Number of hours per week | 4 | of which | Course | 2 | Seminars | 2 | Laboratory | | Project | |
| 3.2 Number of hours per semester | 56 | of which | Course | 28 | Seminars | 28 | Laboratory | | Project | |

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| 3.3 Individual study: | |
| (a) Manual, lecture material and notes, bibliography | 28 |
| (b) Supplementary study in the library, online and in the field | 14 |
| (c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays | 14 |
| (d) Tutoring | 9 |
| (e) Exams and tests | 4 |
| (f) Other activities: | 0 |

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| 3.4 Total hours of individual study (suma (3.3(a)...3.3(f))) | 69 |
| 3.5 Total hours per semester (3.2+3.4) | 125 |
| 3.6 Number of credit points | 5 |

## 4. Pre-requisites (where appropriate)

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| 4.1 Curriculum | High school mathematics, M1. |
| 4.2 Competence | Combinatorics (arrangements, permutations, combinations); sets and operations with sets; mathematical logic; induction method; calculus with matrices; series. |

## 5. Requirements (where appropriate)

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| 5.1. For the course | Blackboard, beamer, computer, graphic tablet |
| 5.2. For the applications | Blackboard, beamer, computer, graphic tablet |

## 6. Specific competence

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| 6.1 Professional competences | |
| 6.2 Cross competences | N/A |

## 7. Discipline objective (as results from the *key competences gained*)

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| 7.1 General objective | Description of fundamental concepts, notions and methods used in counting (enumerative combinatorics) and in discrete probabilities theory Presentation of the basic notions and properties in graphs theory; mathematical models using concepts and methods from graph theory;<br>Basic algorithms and theorems in graph theory and their proofs. |
| 7.2 Specific objectives | Developing strategies and applying specific reasoning methods to solve combinatorial problems;<br>Identifying combinatorial models (patterns) when solving counting problems;<br>Modeling and formulating, in terms and notations specific to probability theory, specific problems involving random experiments and processes;<br>Identifying classical (standard) probabilistic discrete-type models and distributions when solving probability problems;<br>Interpretation of numerical results obtained in problems modeled using random variables;<br>Modeling specific problems, using notions and concepts from graph theory;<br>Application of specific algorithms to classical problems modeled by graph theory (construction of minimum spanning trees, encoding and decoding using binary trees, construction of Eulerian and Hamiltonian walks, the Chinese postman problem, flow problems etc.). |

**8. Contents**

| **8.1 Lectures** | Hours | Teaching methods | Notes |
|---|---|---|---|
| Combinatorics (1): counting principles and methods | 2 | Lecture<br>Learning through discovery<br>Demonstration<br>Analogy<br>Exemplification<br>Collaboration<br>Individual study | |
| Combinatorics (2): Counting problems using recurrence relations. Recurrences and generating functions. | 2 | | |
| Discrete probabilities (1): Axiomatic definition of probability. General formulas and properties. Interpretation of probabilities. Examples. | 2 | | |
| Discrete probabilities (2): Conditional probabilities. Formula on total probability and Bayes formula. | 2 | | |
| Discrete probabilities (3): Classical probability schemes. Discrete random variables. | 2 | | |
| Discrete probabilities (4): Expected value, variance. Examples of discrete random variables with their expected value and variance. | 2 | | |
| Discrete probabilities (5): Weak law of large numbers. Markov theorem, Chebyshev theorem, Poisson theorem. Examples and applications. | 2 | | |
| Graph theory (1): Directed and undirected graphs, multigraphs: definitions, notations, general properties. Examples of problems which can be modelled with graphs. Euler's theorem. | 2 | | |
| Graph theory (2): Walks, trails, paths, cycles. Connectivity in graphs. Isomorphic graphs. Subgraphs. Examples of graphs. Operations with graphs. Trees: general properties. | 2 | | |
| Graph theory (3): Trees, directed trees, rooted trees, spanning trees, minimum spanning trees (MST) in weighted graphs.<br>Algorithms for MST: Prim, Kruskal, Edmonds – Chu-Liu. | 2 | | |
| Graph theory (4): DFS (depth-first-search) and BFS (breadth-first-search) trees. Properties of BFS trees. Minimum path, Dijkstra's algorithm. | 2 | | |
| Graph theory (5): Binary trees, Huffman's algorithm. Greedy algorithms. Property of matroid. | 2 | | |
| Graph theory (6): Matchings. Bipartite graphs. Matchings in bipartite graphs. Maximum matching and complete matching: Hall's and Berge's theorems. | 2 | | |
| Graph theory (7): Transportation networks. Flows and cuts. Max flow min cut theorem. | 2 | | |

| Bibliography |
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| [1] Daniela Roşca – *Discrete Mathematics*, Editura Mediamira, 2008.<br>[2] Sheldon Ross - *A first course in probability,5th ed.*, Prentice Hall, 1997.<br>[3] Norman L. Biggs- *Discrete Mathematics*, Oxford University Press, 2005.<br>[4] Martin Aigner - *Discrete Mathematics,* American Mathematical Society, 2007.<br>[5] Daniela Rosca – *Special Mathematics,* online. |

| **8.2 Applications – Seminars/Laboratory/Project** | Hours | Teaching methods | Notes |
|---|---|---|---|
| Counting problems: Dirichlet's principle, sieve principle, selections. | 2 | Conversation<br>Learning through discovery<br>Demonstration<br>Analogy Exercise<br>Modelling<br>Collaboration<br>Individual study | |
| Counting problems: permutations, arrangements, combinations, with and without repetitions, derangements, combinatorial identities. | 2 | | |
| Counting problems: partitions, integer partitions, distributions, Stirling numbers. | 2 | | |
| Combinatorial identities by double counting. | 2 | | |
| Elementary problems in discrete probabilities, reduced to counting problems, Classical examples with unexpected results. Problems with conditional probabilities. Applications of Bayes' formula with interpretation of the results. | 2 | | |
| Problems reduced to classical probabilities schemes. Discrete random variables. | 2 | | |
| Calculation of expected value and variance for discrete random variables. The method of counter random variables. Application of Chebyshev inequality. | 2 | | |
| Elementary problems with directed and undirected graphs. | 2 | | |
| Graphs representation: adjacency and incidence matrices. Connectivity and adjacency matrices; Foulkes method for finding the connected components. | 2 | | |
| Rooted trees, decision trees, sorting trees. Applications. | 2 | | |
| Isomorphic graphs. | 2 | | |
| Greedy algorithms: vertex coloring, the four colors theorem. | 2 | | |
| Eulerian and Hamiltonian graphs. The Chinese postman problem. | 2 | | |
| Activities networks, critical path. Transportation networks: flow and cut. | 2 | | |

| Bibliography |
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| [1] Hannelore Lisei, Sanda Micula, Anna Soos, *Probability Theory through Problems and applications*, Cluj University Press, 2006.<br>[2] Daniela Rosca – *Special Mathematics*, online. |

**9. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field**

The contents of the discipline are part of the field of discrete, finite, combinatorial mathematics on which the field of computer science and information technology is based. All prestigious universities in the field, without exception, include in their curricula compulsory mathematics subjects (under various names, over several semesters), which cover (and even exceed) the contents of the present subject, being considered essential in the formation of a training on solid foundations in the field of computers and information technology.

**10. Evaluation**

| Activity type | Assessment criteria | Assessment methods | Weight in the final grade |
|---|---|---|---|
| Course | The ability to understand and use the concepts of the discipline in mathematical reasoning applied to specific problems. | Written examination | 50% |

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|---|---|---|---|
| Seminar | The ability to solve problems | Written examination and continuous evaluation during the semester | 50% |
| * For details (according to Art 6.3-2 of the REGULATION REGARDING THE PROFESSIONAL ACTIVITY OF STUDENTS USING THE ECTS SYSTEM): the student evaluation method and the evaluation criteria will be made known to the students by the teaching staff at the first teaching activity. | | | |
| Minimum standard of performance: The ability to understand and use the concepts of the discipline in mathematical reasoning applied to concrete problems. | | | |

| **Date of filling in:** 28.05.2024 | **Responsible** | **Title First name Last name** | **Signature** |
|---|---|---|---|
| | Course | Prof.univ.dr. Daniela Roșca | |
| | Applications | Prof.univ.dr. Daniela Roșca | |
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| Date of approval in the department<br>20.02.2024 | Head of department,<br>Prof.univ. dr. Dorian Popa |
| Date of approval in the Faculty Council<br>22.02.2024 | Dean,<br>Prof.dr.eng. Mihaela Dînșoreanu |