SYLLABUS

1. Data about the program of study

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

2. Data about the subject

2.1 Subject name	***Special Mathematics I***				Subject code	**3**
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 Asist. dr. Andrada Pojar - Andrada.Pojar@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	Formative category: DF – fundamental, DS – speciality, DC – complementary					DF
	Optionality: DOB – mandatory, DOP – optional (alternative), DFA – optional (free choice)					DOB

3. Estimated total time

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	-

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:	-

3.4 Total hours of individual study (sum (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)

4.1 Curriculum	High school mathematics, M1.
4.2 Competence	Knowledge of fundamental concepts in the following areas: combinatorics (arrangements, permutations, combinations), sets and set operations, elements of mathematical logic; the method of mathematical induction; elements of matrix calculus, and series of real numbers.

5. Requirements (where appropriate)

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

6. Specific competence

6.1 Professional competences	• Application of concepts and methods from Combinatorics in solving counting problems, recurrences, and generating functions. • Use of notions from Probability Theory for the analysis of discrete random phenomena and probability computation. • Determination and interpretation of the characteristics of discrete random variables (expected value, variance) and the use of probability distributions in applied contexts. • Modeling and solving problems using Graph Theory. • Analysis of graph structure: connectivity, strongly connected components, isomorphism, trees, and subgraphs. • Application of fundamental graph algorithms (graph traversals, shortest paths, spanning trees, graph coloring, flows, matchings, Eulerian and Hamiltonian graphs, the Chinese postman problem). • Analysis of the efficiency and correctness of the methods and algorithms used.
6.2 Cross competences	• Development of logical, analytical, and structural thinking in problem-solving. • Ability to work independently and to efficiently organize the learning process. • Skills for clear and rigorous communication of mathematical results, both orally and in writing. • Ability to work in a team and collaborate in solving complex problems. • Adoption of a responsible and ethical attitude in the use of probabilistic concepts, including in relation to gambling activities. • Development of the ability to transfer acquired knowledge to practical and interdisciplinary applications.

7. Expected Learning Outcomes

Knowledge	The student/graduate identifies and describes basic concepts, principles and methods in mathematics, physics, chemistry, technical drawing, economics and computer science.
Skills	The student/graduate operates with basic concepts, principles and methods from mathematics, physics, chemistry, technical drawing, economics and computer science. The student/graduate solves problems in mathematics, physics and chemistry with applicability in engineering and validates the solution obtained. The student/graduate performs engineering and economic calculations of medium complexity and associates them with graphical representations or specific computer-aided design. The student/graduate describes physico-chemical and economic phenomena and processes.
Responsibilities and autonomy	The student/graduate applies the values of ethics and deontology of the engineering profession. The student/graduate practices logical reasoning, evaluation and self-evaluation in decision-making. The student/graduate communicates effectively about engineering activities with a wide range of audiences. The student/graduate is engaged in lifelong learning to acquire and implement knowledge, as needed, using appropriate learning strategies. The student/graduate promotes dialogue, cooperation, respect for others and interculturality. The student/graduate works effectively as a team member or leader.

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

8.1 General objective	Formation and development of basic competencies in the field of discrete mathematics through the acquisition of concepts and methods from Combinatorics, Probability Theory (discrete case), and Graph Theory, to model and solve problems specific to computer science and related fields.

8.2 Specific objectives	• Understanding and application of fundamental counting principles and combinatorial methods, development of solution strategies, and application of specific reasoning techniques in solving combinatorial problems. • Acquisition of probability concepts (axiomatic definition, conditional probabilities, fundamental formulas). • Modeling and formulation, in terms and notation specific to Probability Theory, of concrete problems involving random experiments and stochastic processes. • Identification of classical (standard) discrete probability models and distributions in solving probability problems. • Interpretation of numerical results obtained in problems modeled using random variables. • Development of rigorous thinking and a responsible attitude in the interpretation of probabilistic phenomena. • Modeling problems using graphs and identifying relevant types of graphs. • Application of specific algorithms to classical problems modeled through Graph Theory (construction of minimum spanning trees, encoding and decoding using binary trees, construction of Eulerian trails and Hamiltonian paths, the Chinese postman problem, flow problems, etc.).

9. Contents

9.1 Lectures	Hours	Teaching methods	Notes
Combinatorics (1): counting principles and methods	2	Systematic exposition (lecture) of theoretical concepts, using rigorous explanations and illustrative examples. Heuristic dialogue and problem-based learning to stimulate logical thinking and active student participation. Mathematical demonstrations and deductive reasoning for the theoretical foundation of concepts. Guided individual study and assignments for consolidating knowledge.	
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. 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:

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

9.2 Applications - Seminar	Hours	Teaching methods	Notes
Counting problems: Dirichlet's principle, sieve principle, selections.	2		
Counting problems: permutations, arrangements, combinations, with and without repetitions, derangements, combinatorial identities.	2	Learning through problem solving and applied exercises. Heuristic dialogue and problem-based learning to stimulate logical thinking and active student participation, as well as discovery-based learning. Individual study and assignments. Collaboration in solving problems and completing learning tasks.	
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 probability. 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:

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

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

The course content is aligned with the current standards of the scientific community in the field of discrete mathematics and theoretical computer science, reflecting the academic and applied requirements of Combinatorics, Probability Theory, and Graph Theory.
The structure of the course integrates fundamental concepts and classical results (theorems, probabilistic models, discrete structures, and algorithms), which constitute the core of international university curricula in this field. The methods and topics addressed meet the expectations of the epistemic community, with an emphasis on mathematical rigor, formalization, proof, and modeling.
Furthermore, the inclusion of fundamental graph theory algorithms, discrete probabilistic models, and classical

graph optimization problems ensures compatibility with current research and application directions in computer science, combinatorial optimization, and network theory.
Through this approach, the course contributes to the formation of an academic profile consistent with the requirements of the scientific community, which values both solid theoretical foundations and the ability to apply concepts in solving complex and interdisciplinary problems.

11. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Level of understanding of fundamental concepts in combinatorics. Ability to analyze and interpret discrete random variables and their numerical characteristics (mean, variance), as well as probability distributions. Understanding and application of concepts from Graph Theory in modeling and solving problems. Rigor of mathematical reasoning and correctness of proofs and calculations.	Written examination	40%
Seminar	Correctness and completeness in solving the proposed problems. Correct use of concepts from Probability Theory in problem solving. Correct application of fundamental algorithms and methods for solving graph-related problems. Ability to interpret results in an applied context.	Written examination and continuous evaluation during the semester	60%
Minimum standard of performance: Ability to present a theoretical topic in a coherent manner and ability to solve problems. Conditions for participation in the final examination: maximum 4 seminar absences, according to the ECTS Regulations of UTCluj. Conditions for passing: CP>=5, G>=5, CP+G>=35, where CP = points from counting + probabilities (min 0, max 45), G = points from graphs (min 0 max 45) . Calculation of final mark: (CP+G)/10.			

Date of filling in:	Responsible	Title, First name Last name	Signature
24.04.2026	Course	Prof.univ.dr. Daniela ROȘCA	
	Applications	Prof.univ.dr. Daniela ROȘCA	
		Asist. univ. dr. Andrada POJAR	

Date of approval in the department	Head of department, Prof.univ. dr. Dorian Popa
Date of approval in the Faculty Council	Dean, Prof.dr.eng. Vlad Mureșan