MINISTERUL EDUCAŢIEI ȘI CERCETĂRII
UNIVERSITATEA „AUREL VLAICU" DIN ARAD
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Operator de date cu caracter personal nr.2929

SYLLABUS

1. Study programme

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Full-time education**

2. Course details

2.1. Name of the discipline	**GmEA1O01 Special chapters of algebra**
2.2. Education Plan Holder	**Prof. Dr. Moț Ghiocel**
2.3. Assistant	**Prof. Dr. Moț Ghiocel**
2.4. Year of study	**1**
2.5. Semester	**1**
2.6. Type of evaluation	**SE**
2.7. Discipline regime	**Compulsory**

3. Estimated total time (hours per semester of teaching activities)

3.1. Number of hours per week	**2**
3.2. Class hours per week	**1**
3.3. Seminar/laboratory/project hours per week	**1**
3.4. Total hours in the curriculum	**28**
3.5. Course hours per semester	**14**
3.6. Seminar/laboratory/project hours per semester	**14**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**30**
3.4.2. Additional documentation in the library, on specialized electronic platforms and on land	**30**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**30**
3.4.4. Tutoring	**3**
3.4.5. Examinations	**4**
3.4.6. Other activities ...	**0**
3.7. Total hours of individual study	**97**
3.8. Total hours per semester	**125**
3.9. Number of credits	**5**

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	
4.2. Competence prerequisites	

5. Necessary conditions (where applicable)

5.1. Course conditions	**Whiteboard** **Video projector, Internet connection**
5.2. Conditions for holding the seminar	**Whiteboard** **Computer/Laptop, Internet connection**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C1. Performs analytical mathematical calculations.** **C3. Thinks abstractly.** **C4. Communicates mathematical information.** **C10. Apply scientific methods.**
6.2. Transversal skills	**CT1. Think analytically.** **CT2. Approach challenges positively.** **CT3. He pays attention to details.** **CT4. Works efficiently.**

7. Discipline objectives (where applicable)

7.1. General objective of the discipline	**- The student deepens the knowledge of algebra already acquired.** **- The student develops the skills to correctly apply the acquired knowledge to solve different classes of problems.** **- The student must train and develop his analytical ability.**
7.2. Specific objectives	**- The student is able to correctly apply basic methods and principles in solving complex problems.** **- The student is able to select appropriate methods and techniques for solving algebra problems.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. Tensor Calculus 1.1. Linear and bilinear forms. 1.2. Forms quadratic and canonical forms 1.3. Dual and bi-dual vector spaces. Dual basis, canonical isomorphism. 1.4. Multilinear applications and multilinear forms. Tensors. 1.5. Operations with tensors. Applications in quantum information theory. 1.6. Addition (sum) of tensors.Scalar product of a tensor. Tensor product of two tensors 1.7. Contraction operation of a tensor. Contracted tensor product. Inner product.	Lecture, debate, demonstration, exemplification	7 hours
2. The ring of polynomials 2.1. Rings of polynomials. Rings of polynomial functions 2.2. Symmetric polynomials Symmetric rational fractions 2.3. Divisibility and association relation in divisibility in commutative monoids with simplification. Cmmdc and cmmmc Prime and irreducible elements 2.4. Factorial semigroups. Divisibility and association relation in divisibility in domains of integrity. Connection with principal ideals. Factorial domains 2.5. Domains with principal ideals. Euclidean domains. Divisibility in rings of Polynomials 2.6. Prime ideals and maximal ideals. Characteristic of a ring with unity. Prime subfield. Prime fields. 2.7. Degree of an extension of fields. Finite extensions. Algebraic extensions. Algebraic elements, minimal polynomial.	Lecture, debate, demonstration, exemplification	7 hours

8.2. Course Bibliography

1. **R. Larson, Elementary linear algebra, Brooks Cole, 2016.**
2. **G.M Ionescu, Tensor Calculus for Engineering Sciences, Ed. Agir, 2007.**
3. **G. Moț, Seminar and course notes- Special chapters of algebra, SUMS, 2025.**
4. **G. Moț, CL Mihiț, Algebra. Seminar and course support, "Aurel Vlaicu" Univ. Publishing House Arad, 2019, 162 pages, ISBN: 978-973-752-809-4.**
5. **G. Moț, L. Popa, Linear algebra. Analytical and differential geometry. "Aurel Vlaicu" Arad University Publishing House, 2015, 160 pages, ISBN: 978-973-752-715-8.**

6. P. J. Olver, C. Shakiban, Applied Linear Algebra, Undergraduate Texts in Mathematics, 2018.

8.3. Seminar Content	Teaching methods	Observations
1. Tensor calculus 1.1. Linear forms and bilinear forms. 1.2. Quadratic forms and canonical forms 1.3. Dual and bidual vector spaces. Dual basis, canonical isomorphism. 1.4. Multilinear applications and multilinear forms. Tensors. 1.5. Operations with tensors. Applications in quantum information theory. 1.6. Addition (sum) of tensors.. Scalar product of a tensor. Tensor product of two tensors 1.7. Contraction operation of a tensor. Contracted tensor product. Inner product.	Exercise, discussion and debate, modeling, project	7 hours
2. The ring of polynomials 2.1. Rings of polynomials. Rings of polynomial functions 2.2. Symmetric polynomials Symmetric rational fractions 2.3. Divisibility and association relation in divisibility in commutative monoids with simplification. Cmmdc and cmmmc Prime and irreducible elements 2.4. Factorial semigroups. Divisibility and association relation in divisibility in domains of integrity. Connection with principal ideals. Factorial domains 2.5. Domains with principal ideals. Euclidean domains. Divisibility in rings of Polynomials 2.6. Prime ideals and maximal ideals. Characteristic of a ring with unity. Prime subfield. Prime fields. 2.7. Degree of an extension of fields. Finite extensions. Algebraic extensions. Algebraic elements, minimal polynomial.	Exercise, discussion and debate, modeling, project	7 hours

8.4. Seminar Bibliography

1. **R. Larson, Elementary linear algebra, Brooks Cole, 2016.**
2. **G.M Ionescu, Tensor Calculus for Engineering Sciences, Ed. Agir, 2007.**
3. **G. Moț, Seminar and course notes- Special chapters of algebra, SUMS, 2025.**
4. **G. Moț, CL Mihiț, Algebra. Seminar and course support, "Aurel Vlaicu" Univ. Publishing House Arad, 2019, 162 pages, ISBN: 978-973-752-809-4.**
5. **G. Moț, L. Popa, Linear algebra. Analytical and differential geometry. "Aurel Vlaicu" Arad University Press, 2015, 160 pages, ISBN: 978-973-752-715-8.**
6. **P. J. Olver, C. Shakiban, Applied Linear Algebra, Undergraduate Texts in Mathematics, 2018.**

8.5. Laboratory Content	Teaching methods	Observations
8.6. Laboratory Bibliography		
8.7. Project Content	Teaching methods	Observations
8.8. Project Bibliography		

9. Corroboration/validation of the course contents (where applicable)

This course is taught in similar programs at several universities, both in the country and abroad. In order to better match the demands of the labor market, meetings were organized with representatives of employers and with specialized teachers from the pre-university education system. The use of English brings and adds value to the program, allowing the employment of graduates by multinational companies (both from abroad and from Romania).

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight from the final grade
10.3. Course	**- knowledge; logical coherence; acquisition of specialized language; criteria targeting attitudinal aspects: seriousness, conscientiousness, interest in the topic addressed.**	Oral assessment: presentation of a final project; free presentation; oral questions. Active participation in course	40% 10%
10.2. Seminar	**- the ability to operate with the acquired knowledge; the ability to apply it in practice; conscientiousness and interest in studying.**	Oral assessment: preparation and presentation of the final project. Active participation in the seminar	40% 10%
10.3. Laboratory			
10.4. Project			
10.5 Minimum performance standard **Learning basic concepts, using specialized language, making a simple application.**			

11. Learning outcomes

Knowledge: The graduate: -knows advanced concepts in mathematical analysis, algebra, analytical geometry, differential equations, etc.; -understands the theories, formulas and techniques of analytical calculus: derivation, integration, limits, series, transformations; -knows the methods of analytical and numerical solution of equations and problems with initial or boundary conditions; -defines the concepts Understands the fundamental concepts underlying abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types; -knows the principles of mathematical and formal logic, as well as demonstration methods; -formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples; -knows advanced mathematical terminology, in Romanian and English; -knows the conventions of notation, symbolization and formal presentation of mathematical content; -translates various practical problems into mathematical language; -is able to express mathematical problems/theorems with practical implications in everyday language; -constructively approaches scientific texts on a given topic; -selects and organizes the information necessary to carry out research; -compares and distinguishes related notions and their properties from advanced mathematical disciplines; -knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analyzing the results, validating or rejecting the hypothesis; -demonstrates advanced knowledge of the concepts and models of analytical thinking, including logical reasoning, causal analysis, critical evaluation of information and evidence-based decision-making; -understands methods for structuring complex problems, such as SWOT analysis, decision analysis, logical modeling and systemic approaches; -knows techniques for evaluating the validity and coherence of arguments, in academic and professional contexts; -knows the concepts and theories related to resilience, emotional intelligence and positive thinking, applicable in professional and personal contexts; -understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies; -knows models of positive leadership and change management, relevant for constructively addressing challenges in teams and organizations; -knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research and decision-making; -understands the impact of minor errors on the final results, in contexts such as data analysis, scientific writing, project management or professional communication; -knows methods and techniques for quality verification and control, applicable in various fields of activity; -knows principles and methods of efficient organization of activity, including planning, prioritizing tasks and time management; -understands the concepts of personal productivity and professional performance, in individual and team contexts; -knows digital tools and modern activity management techniques, useful for optimizing work processes.

Skills: The graduate: - correctly performs complex analytical mathematical calculations, applying rules and theorems in a rigorous manner; - uses various computing technologies to perform analytical mathematical calculations and establish solutions to a problem in the field; - solves equations and logical-mathematical problems; - provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the curriculum disciplines; - represents and formulates concepts and problems in abstract, symbolic or formal terms; - creates abstract representations for computer structures: trees, graphs, recursive functions, object classes; - writes rigorous demonstrations, logical arguments and detailed explanations, using specific language; - develops the solution to a problem in the field using appropriate symbols, language and mathematical tools; - interprets and explains graphs, tables, mathematical models, numerical or symbolic results; -applies scientific methods and techniques to investigate current phenomena or practical problems; -corrects and integrates previous knowledge into current studies; -uses digital technology in the studies undertaken; -recognizes and analyzes the necessary and/or sufficient conditions in the statement of mathematical assertions and specifies their role in the demonstration; -analyzes complex problems by breaking them down into essential components, identifying causal relationships and relevant factors; -critically evaluates information and arguments, identifying reasoning errors, cognitive biases and sources of uncertainty; -formulates rational and well-argued solutions, based on data, facts and logical principles; -applies analytical methods in decision-making, in interdisciplinary contexts and under conditions of uncertainty; -identifies and analyzes challenges objectively, maintaining a balanced and solution-oriented attitude; -applies emotional self-regulation and effective communication strategies, in order to manage conflicts and pressures constructively; -transforms obstacles into learning and development opportunities, demonstrating cognitive flexibility and openness to change; -encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate; -identifies inconsistencies, errors or omissions in documents, data or processes, demonstrating a rigorous and systematic approach; -applies review and verification techniques to ensure the correctness and coherence of information; -respects formatting, structuring and presentation standards in writing texts, reports or scientific papers; -monitors details in complex activities, without losing sight of the overall objectives of the project; -plans and structures activities effectively, setting clear objectives, realistic deadlines and adequate resources; -manages time and workload, adapting to priorities and deadlines without compromising quality; -uses agile or traditional working tools and methods to increase efficiency in individual or collaborative projects; -monitors progress and optimizes work processes, identifying and eliminating bottlenecks or resource losses.

Responsibility and autonomy: The graduate: -has the ability to perform complex calculations; -verifies and validates the results obtained through critical analysis; -assumes responsibility in choosing the correct calculation methods; -applies efficient work techniques in multidisciplinary teams; -manifests intellectual autonomy in exploring and manipulating abstract concepts; -finds solutions to practical, operational or conceptual problems, in a wide range of contexts; -generates argumentative procedures in support of solutions; -communicates and interprets the solution to a problem; -compares using specific mathematical language, alternative solutions; -presents ideas and processes using appropriate mathematical symbols, language and tools; -manifests rigor and intellectual discipline in writing and presenting their own mathematical results; -writes, edits and presents scientific texts; -assumes responsibility for the correctness, coherence and clarity of the information presented; -responsibly analyzes and interprets the results of the scientific research carried out; -adapts routine problem-solving techniques and strategies to solving synthesis problems and those with a higher degree of complexity; -assumes responsibility for the quality of the analysis process, demonstrating rigor, objectivity and coherence in reasoning; -makes autonomous decisions in complex situations, based on a critical assessment of alternatives and consequences; -promotes analytical thinking in teams and organizations, contributing to the development of a culture of reflection and informed decision-making; -demonstrates initiative in applying analytical thinking to solve real problems, in academic, professional or social contexts; -assumes responsibility for one's own reactions to challenges, demonstrating emotional maturity and professionalism; -makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective; -acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture; -promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment; -takes responsibility for the accuracy of one's own work, demonstrating rigor and professionalism in delivering results; -works autonomously with a high level of attention to detail, even under pressure or deadlines; -contributes to maintaining quality standards in the team, providing constructive feedback and supporting quality control processes; -demonstrates consistency and discipline in verification and validation activities, contributing to reducing risks and increasing efficiency; -takes responsibility for achieving the set objectives, demonstrating consistency and results orientation; -works autonomously and efficiently in complex contexts, maintaining a balance between quality, time and resources; -contributes to making the team's work more efficient, by proposing solutions and good organizational practices; -demonstrates initiative in continuously improving the way of working, adapting to changes and learning from experience.

Titular	Assistant	Head of the Department	DEAN
Professor Dr. Moț Ghiocel	Professor Dr. Moț Ghiocel	Conf.univ.dr. Lorena Camelia Popa	Prof. Sorin-Florin NĂDĂBAN, PhD

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DISCIPLINE SHEET

1. Program Data

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Part-time education (FI)**

2. Data about Discipline

2.1. Name of the discipline	**GmEA1O02 Operators on Hilbert spaces**
2.2. Education Plan Holder	**Associate Professor Dr. Gaspar Octavian Pastorel**
2.3. Assistant	**Associate Professor Dr. Gaspar Octavian Pastorel**
2.4. Year of study	1
2.5. Semester	1
2.6. Type of evaluation	**IS**
2.7. Discipline regime	**At**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**
3.2. Class hours per week	**2**
3.3. Seminar/laboratory/project hours per week	**1**
3.4. Total hours in the curriculum	**42**
3.5. Course hours per semester	**28**
3.6. Seminar/laboratory/project hours per semester	**14**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**40**
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	**30**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**35**
3.4.4. Tutoring	**0**
3.4.5. Examinations	**3**

3.4.6. Other activities ...	0
3.7. Total hours of individual study	**108**
3.8. Total hours per semester	**150**
3.9. Number of credits	6

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	**Real and complex analysis** **Functional analysis**
4.2. Competence prerequisites	**the ability to extract relevant information from international specialized literature**

5. Necessary conditions (where applicable)

5.1. Course conditions	**classroom equipped with blackboard and video projector**
5.2. Conditions for holding the seminar	**seminar room equipped with a whiteboard and video projector**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C2. Synthesizes information** **C3. Thinks abstractly C4.** **Communicates mathematical information** **C5. Studies relationships between** **quantities C10. Apply scientific methods**
6.2. Transversal skills	**CT1. Thinks analytically** **CT2. Approaches challenges positively CT3. Pays attention to details** **CT4. Works efficiently**

7. Discipline objectives (where applicable)

7.1. Objective general of the discipline	**- Accumulation of knowledge regarding unbounded operators and elements of spectral theory for them.** **- The student should develop the skills to correctly apply the acquired knowledge to solve different classes of problems.** **- The student must train and develop his analytical ability.**
7.2. Specific objectives	**- The student is able to demonstrate that he/she has acquired sufficient knowledge to understand concepts such as: closed operator, dense defined operator, normal operator, self-adjoint operator, symmetric operator, Hermitian operator, spectrum of an operator - The student is able to correctly apply basic methods and principles in solving complex problems.** **- The student can carry out projects for the mathematical modeling of a concrete problem.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. General and specific notions about Hilbert spaces: inner product, orthogonality, projection theorem, orthonormal bases 2. General and specific notions about operators on Hilbert spaces: bounded operators, continuous operators, Riesz representation of linear and continuous functionals, norm of an operator, dense defined operator, adjoint of an operator, orthogonal projectors, graph of an operator 3. Closed operators 4. Differential operators 5. Spectrum of a closed operator 6. Accretive and sectorial operators	Interactive exhibition	

8.2 Course Bibliography

K. Schmudgen, Unbounded Self-adjoint Operators on Hilbert Space, GTM: 265, Springer, 2012 J. Weidmann, Linear Operators in Hilbert Spaces, GTM: 68, Springer, 1980

8.3 Seminar Content	Teaching methods	Observations
1. General and specific notions about Hilbert spaces: inner product, orthogonality, projection theorem, orthonormal bases 2. General and specific notions about operators on Hilbert spaces: bounded operators, continuous operators, Riesz representation of linear and continuous functionals, norm of an operator, dense defined operator, adjoint of an operator, orthogonal projectors, graph of an operator 3. Closed operators 4. Differential operators 5. Spectrum of a closed operator 6. Accretive and sectorial operators	Exercise, discussions and debate, modeling, project	

8.4 Seminar Bibliography

K. Schmudgen, Unbounded Self-adjoint Operators on Hilbert Space, GTM: 265, Springer, 2012 J. Weidmann, Linear Operators in Hilbert Spaces, GTM: 68, Springer, 1980

8.5 Laboratory Content	Teaching methods	Observations

8.6 Laboratory Bibliography

8.7 Project Content	Teaching methods	Observations

8.8 Project Bibliography

9. Corroboration/validation of the content of the discipline (where applicable)

The content of the discipline is consistent with what is done in other university centers abroad.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade
10.1. Course	**- correctness and completeness of knowledge; - logical coherence; - degree of assimilation of specialized language; - criteria targeting attitudinal aspects: conscientiousness, interest in individual study.**	Oral assessment: student's free presentation; oral questionnaire; evaluation conversation	60%
10.2. Seminar	**- the ability to operate with the acquired knowledge; - the ability to apply it in practice;**	individual project	40%
10.3. Laboratory			
10.4. Design			

10.5 Minimum performance standard

Knowledge of the fundamental elements of theory, logical coherence in exposition, solving a simple application.

11. Learning outcomes

Knowledge: C2. Synthesizes information: The graduate: a) documents himself/herself in relation to a given topic b) knows ways of collecting, classifying and evaluating information from various sources c) critically summarizes new and complex information in relation to a given topic C 3. Thinks abstractly: The graduate: a) defines concepts understands the fundamental concepts that underlie abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types b) Knows the principles of mathematical and formal logic, as well as demonstration methods c) formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples C 4.
Communicates mathematical information: The graduate: a) Knows advanced mathematical terminology, in Romanian and English b) Knows the conventions of notation, symbolization and formal presentation of mathematical content c) Transposes various practical problems into mathematical language d) Is able to express mathematical problems/theorems with practical implications in ordinary language C5. Studies relationships between quantities The graduate a) Has the ability to analyze and interpret complex relationships between quantities in interdisciplinary contexts b) Knows advanced methodologies for modeling and verifying relationships between

quantities c) Can develop and evaluate hypotheses based on relationships between quantities in scientific research d) Has the ability to communicate and argue relationships between quantities in a clear and academic manner C10. Apply scientific methods The graduate: a) Constructively approaches scientific texts on a given topic b) Selects and organizes the information necessary to carry out research c) Compares and distinguishes related notions and their properties from advanced mathematical disciplines. d)
Knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analyzing the results, validating or rejecting the hypothesis Skills C2: The
graduate: a) correctly interprets the information collected on a given topic b) classifies the information available according to the context c) selects the information necessary to solve a specific problem d) uses digital tools to support information synthesis. C3: The graduate: a) provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the curriculum subjects. b) represents and formulates concepts and problems in abstract, symbolic or formal terms c) creates abstract representations for computer structures: trees, graphs, recursive functions, object classes C4: The graduate: a) Writes rigorous demonstrations, logical arguments and detailed explanations, using specific language b)

Develops a solution to a problem in the field using appropriate mathematical symbols, language and tools c)
Interprets and explains graphs, tables, mathematical models, numerical or symbolic results C5: The graduate: a) Can examine and interpret relationships between variables in advanced mathematical, economic, scientific or social problems b) Can use statistical, mathematical or computational techniques to build and validate models involving relationships between variables. c) Can formulate and test hypotheses related to quantitative relationships within research projects. d) Can write reports, presentations or scientific publications that highlight and interpret relationships between variables. C10: The graduate: a) Apply scientific methods and techniques to investigate current phenomena or practical problems b) Corrects and integrates previous knowledge in current studies c) Uses digital technology in studies undertaken d) Recognizes and analyzes the necessary and/or sufficient conditions in the statement of mathematical assertions and specifies their role in the demonstration.

Responsibility and autonomy C2: The graduate: a) uses the information at his disposal coherently b) demonstrates professionalism in managing the information at his disposal c) can work autonomously or in multidisciplinary teams C3: The graduate: a) Demonstrates intellectual autonomy in exploring and manipulating abstract concepts b) finds solutions to practical, operational or conceptual problems, in a wide range of contexts c) generates argumentative procedures in support of solutions C4: The graduate: a) Communicates and interprets the solution to a problem b) Compares alternative solutions using specific mathematical language c) Presents ideas and processes using appropriate mathematical symbols, language and tools d) Demonstrates rigor and intellectual discipline in writing and presenting his own mathematical results C5: The graduate a) Assumes responsibility for the validity and accuracy of the interpretation of the data and relationships identified. b) Takes the freedom to choose techniques and tools relevant to the specifics of the problem, assuming responsibility for the results obtained. c) Autonomously manages the research process, ensuring scientific rigor and academic integrity. d) Assumes responsibility for presenting and explaining conclusions clearly and with justification, assuming independence in writing and supporting scientific papers. C10: The graduate: a) Writes, edits and presents scientific texts b) Assumes responsibility for the correctness, coherence and clarity of the information presented c) Analyzes and interprets the results of scientific research carried out responsibly d) Adapts techniques and strategies for solving routine problems to solving synthesis problems and problems with a higher degree of complexity

Professor	Assistant	Director Department	DEAN
Associate Professor Dr. Gaspar Octavian Pastorel	Gaspar Octavian Pastorel, PhD	Conf.univ.dr. Lorena Camelia Popa	Prof. Sorin-Florin NADABAN, PhD

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1. Program Data

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Full-time education (FT)**

2. Data about Discipline

2.1. Name of the discipline	**GmEU1O03 Special chapters of mathematical analysis**
2.2. Education Plan Holder	**Prof. Dr. Nădăban Sorin Florin**
2.3. Assistant	**Lect. Dr. Sida Lavinia Elisabeta**
2.4. Year of study	**1**
2.5. Semester	**1**
2.6. Type of evaluation	**ES**
2.7. Discipline regime	**OB**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**2**
3.2. Class hours per week	**1**
3.3. Seminar/laboratory/project hours per week	**1**
3.4. Total hours in the curriculum	**28**
3.5. Course hours per semester	**14**
3.6. Seminar/laboratory/project hours per semester	**14**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**40**
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	**20**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**30**
3.4.4. Tutoring	**3**
3.4.5. Examinations	**4**

3.4.6. Other activities ...	**0**
3.7. Total hours of individual study	**97**
3.8. Total hours per semester	**125**
3.9. Number of credits	**5**

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	**Fundamental knowledge of mathematics**
4.2. Competence prerequisites	**Operating with mathematical concepts.**

5. Necessary conditions (where applicable)

5.1. Course conditions	**Properly equipped classroom.**
5.2. Conditions for holding the seminar	**Properly equipped seminar room.**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C1. Performs analytical mathematical calculations** **C3. Thinks abstractly** **C4. Communicates mathematical information** **C10. Apply scientific methods**
6.2. Transversal skills	**CT1. Think analytically** **CT2. Approach challenges positively** **CT3. He pays attention to details** **CT4. Works efficiently**

7. Discipline objectives (where applicable)

7.1. General objective of the discipline	**Students will acquire advanced knowledge of mathematical analysis.**
7.2. Specific objectives	**Students will acquire advanced knowledge of mathematical analysis.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
Chapter 1. Continuity, functions with the Darboux property, derivability, primitivity. Chapter 2. Metric spaces and Continuous functions. Chapter 3. Functions with bounded variation. Riemann-Stieltjes integral.	• Interactive lecture • The debate • Problematization	

8.2 Course Bibliography

1. S. Nădăban, Calculus - Elemente de calcul diferenţial şi integral, Mirton Publishing House, Timișoara, 2010, 133 pages, ISBN:978-973-52-0931-5.

2. Fihtenholtz G.M.: Curs de calcul diferenţial şi integral I, II, III, ET 1965

3. Mot, G., Gaga, L., Bulzan, T., Popa, L., Sida, L., Ila, G., Matematici superioare pentru ingineri şi economişti vol. I, Ed. The Life of Arad, Arad, 2000, 256 p, ISBN: 973–9454–38-4

4. Mot, G., Gaga, L., Bulzan, T., Popa, L., Sida, L., Ila, G., Matematici superioare pentru ingineri şi economişti vol. II, Ed. Life in Arad, Arad, 2000, 270 p, ISBN: 973–9454–37-2

5. Mot, G., Gaga, L., Bulzan, T., Popa, L., Sida, L., Exerciţii şi probleme de matematici superioare pentru profilurile tehnic şi economic, Ed. Viața arădeană, Arad, 2003, 630 p, ISBN: 973–86–288-2-2

6. Ceaușu, T., Capitole speciale de analiză matematică, Ed. Matrix Rom, 2018

7. Stănășilă O., Analiză matematică, Didactic and pedagogical publishing house, Bucharest, 1981

8. Friedman, A.: Foundations of Modern Analysis, Dover Publications, Paperback Edition, July 21, 2010

9. Kantorovitz, S., Introduction to Modern Analysis, Oxford University Press, 2003, 2nd ed. 2006.

10. Rudin, Walter (1976). Principles of Mathematical Analysis (3rd ed.). New York: McGraw-Hill. ISBN 978-0070542358.

11. Apostle, Tom M. (1974). Mathematical Analysis (2nd ed.). Addison–Wesley. ISBN 978-0201002881.

12. Wilansky, Albert (2013). Modern Methods in Topological Vector Spaces. Mineola, New York: Dover Publications, Inc. ISBN 978-0-486-49353-4. OCLC 849801114.

13. Bartle, Robert G.; Sherbert, Donald R. (2011). Introduction to Real Analysis (4th ed.). New York: John Wiley and Sons. ISBN 978-0-471-43331-6.

14. Carothers, Neal L. (2000). Real Analysis. Cambridge: Cambridge University Press. ISBN 978-0521497565.

8.3 Seminar Content	Teaching methods	Observations
Chapter 1. Continuity, functions with the Darboux property, differentiability, primitivity. Chapter 2. Metric spaces and continuous functions. Chapter 3. Functions with bounded variation. Riemann-Stieltjes integral.	• Interactive lecture •The debate • Problematization	

8.4 Seminar Bibliography

1. S. Nădăban, Calculus - Elements of differential and integral calculus, Ed.Mirton, Timișoara, 2010, 133 pages, ISBN:978-973-52-0931-5.

2. Fihtenholtz G.M.: Curs de calcul diferenţial şi integral I, II, III, ET 1965

3. Mot, G., Gaga, L., Bulzan, T., Popa, L., Sida, L., Ila, G., Matematici superioare pentru ingineri şi economişti vol. I, Ed. Viața Arădeană, Arad, 2000, 256 p, ISBN: 973–9454–38-4

4. Mot, G., Gaga, L., Bulzan, T., Popa, L., Sida, L., Ila, G., Matematici superioare pentru ingineri şi economişti vol. II, Ed. Viaÿa arÿdeanÿ, Arad, 2000, 270 p, ISBN: 973–9454–37-2

5. Mot, G., Gaga, L., Bulzan, T., Popa, L., Sida, L., Exerciţii şi probleme de matematici superioare pentru profilurile tehnic şi economic, Ed. Viața arădeană, Arad, 2003, 630 p, ISBN: 973–86–288-2-2

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7. Stănăşilă O., Analiză matematică, Didactic and pedagogical publishing house, Bucharest, 1981

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11. Apostle, Tom M. (1974). Mathematical Analysis (2nd ed.). Addison–Wesley. ISBN 978-0201002881.

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14. Carothers, Neal L. (2000). Real Analysis. Cambridge: Cambridge University Press. ISBN 978-0521497565.

8.5 Laboratory Content	Teaching methods	Observations

8.6 Laboratory Bibliography

8.7 Project Content	Teaching methods	Observations

8.8 Project Bibliography

9. Corroboration/validation of the content of the discipline (where applicable)

The content of the discipline is consistent with the content of similar disciplines from other university centers in the country and abroad. For a better adaptation of the content of the discipline to the requirements of the labor market, meetings were held with both employers - representatives of the business environment and with mathematics and computer science teachers from the pre-university education in Arad.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight from the final grade
10.1. Course	**Preparing and presenting a report**	Oral evaluation (final in the exam session): Presentation of a final project Student's free presentation Evaluation conversation Oral questionnaire.	80%
10.2. Seminar	**The ability to operate with the acquired knowledge; - the ability to apply it in practice - conscientiousness, interest in study.**	Oral evaluation (final in the exam session): Completion and presentation of the final project. Homework, projects completed along the way. Active participation in the seminar.	20%
10.3. Laboratory			

10.4. Design			

10.5 Minimum performance standard

Mastering fundamental concepts, using specialized language, creating an application.

11. Learning outcomes

1) Demonstrates advanced knowledge of analytical thinking concepts and models, including logical reasoning, causal analysis, critical evaluation of information, and evidence-based decision-making. 2) Understands methods for structuring complex problems, such as SWOT analysis, decision analysis, logic modeling, and systems approaches. 3) Knows techniques for evaluating the validity and coherence of arguments, in academic and professional contexts. 4) Knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research, and decision-making. 5) Understands the impact of minor errors on final results, in contexts such as data analysis, scientific writing, project management, or professional communication. 6) Knows methods and techniques for verification and quality control, applicable in various fields of activity. 7) Knows principles and methods for effective organization of work, including planning, prioritizing tasks, and time management. 8) Understands the concepts of personal productivity and professional performance, in individual and team contexts. 9) Knows digital tools and modern activity management techniques, useful for optimizing work processes.

Course holder	Assistant	Director of the Department	Dean
Prof. Nădăban Sorin Florin	Lect. Sida Lavinia Elisabeta	Assoc. Prof. Popa Lorena Camelia	Prof. Nădăban Sorin Florin

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SYLLABUS

Academic year 2025-2026

Study year 1 / Semester 1

Legend:
- written in black - standard format of the subject sheet
- written in blue - operational suggestions for developing the sheet.

1. Program data

1.1 Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2 Faculty	**of Exact Sciences**
1.3 Department	**Department of Mathematics-Informatics**
1.4 Field of study	**Mathematics**
1.5 Study cycle	**Master's degree**
1.6 COR/ESCO core group study/qualification program *	**Mathematical modeling in science and technology**

* according to the Curriculum

2. Data about the discipline

2.1. Name of the discipline	**Shape optimization**			2.2 Discipline code		**GmEU1O04**	
2.3. Course activity holder			**Assoc. Prof Bogosel Beniamin**				
2.4 Seminar/laboratory activity holder			**Assoc. Prof Bogosel Beniamin**				
2.5 Year of study	**1**	2.6 Semester	**1**	2.7 Evaluation type (E/C/VP)	**ES**	2.8 Discipline regime (O-mandatory, **Op**-Optional, **F**-optional)	**OB**

3. Total estimated time

3.1 Number of hours per week	**3**	of which: 3.2 course	**2**	3.3 seminar/laboratory	**1**
3.4 Total hours in the curriculum	**42**	of which: 3.5 course	**28**	3.6 seminar/laboratory	**14**
Time distribution					**hours**
a. Study according to the textbook, course material, bibliography and notes					**108**
b. Additional documentation in the library, on specialized electronic platforms and in the field					**0**

c. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**0**
d. Tutoring	**0**
e. Examinations	**0**
f. Other university activities (study visits, project consultations, etc.)	**0**

3.7 Total hours of individual study (a+b+c)	**108**
3.8 Total hours of university activities (d+e+f+3.4)	**42**
3.9 Total hours per semester (3.7+3.8)	**150**
3.10 Number of credits **	**6**

* 1 credit = 25 hours
** It is recommended that 3.7 be greater than or equal to 3.8

4. Preconditions(where applicable)

4.1 curriculum	Differential and integral calculus in R^n
4.2 competencies	-

5. Conditions(where applicable)

5.1 Course schedule	Classroom, equipped with laptop, video projector and appropriate software, Internet access - accounts in the SUMS platform
5.2 Seminar schedule	Classroom, equipped with laptop, video projector and appropriate software, Internet access - accounts in the SUMS platform
5.3 Laboratory conduct	-
5.4 Project implementation	-

6. Specific skills acquired

6.1 Professional skills	C1. Operating with advanced notions and methods of functional and numerical analysis. C3. Solving problems of dynamic systems, optimal control and operational research.

6.2 Transversal skills	CT1. Manifesting a responsible attitude towards the scientific and didactic field, capitalizing on their own professional potential, compliance with rigorous and efficient work rules for performing complex professional tasks. CT3. Selection of information resources, efficient use of professional training sources, developing the ability to correlate professional activity with the requirements of a dynamic society

7. Discipline objectives(based on the grid of specific skills acquired)

7.1 General objective of the discipline	- presenting a general introduction to the field of shape optimization through examples and applications
7.2 Specific objectives	- introductory concepts in mathematical optimization theory - the study of isoperimetric problems - study of the existence of optimal shapes, differential calculus on the space of shapes - numerical approximation of optimal shapes

8. Contents *

8.1 Course	Teaching methods	Observations
1. Introductory aspects: mathematical optimization, geometric notions 2. Isoperimetric problem: history, dimension 2, dimension N, discrete problem 3. Theory of the existence of optimal shapes: the study of topology on the space of shapes, applications 4. Differential calculus on shape space 5. Numerical approximation of optimal shapes	Participatory lecture, debate, presentation, Problem Participatory lecture, debate, presentation, Problem Participatory lecture, debate, presentation, Problem Participatory lecture, debate, presentation, Problem Participatory lecture, debate, presentation, Problem	4 hours 8 hours 4 hours 6 hours 6 hours
8.2 Bibliography 1. A. Henrot, M. Pierre, Shape Variation and Optimization - A geometric analysis, EMS Press, 2018 2. G. Allaire, Conception optimale des structures, Springer, 2007 3. B. Bogosel - course support and applications - SUMS Platform.		
8.3 Seminar	**Teaching methods**	**Observations**

1. Introductory aspects: mathematical optimization, geometric notions 2. Isoperimetric problem: history, dimension 2, dimension N, discrete problem 3. Theory of the existence of optimal shapes: the study of topology on the space of shapes, applications 4. Differential calculus on shape space 5. Numerical approximation of optimal shapes	Exercise, discussions and debate, modeling, the project. Exercise, discussions and debate, modeling, the project. Exercise, discussions and debate, modeling, the project. Exercise, discussions and debate, modeling, the project. Exercise, discussions and debate, modeling, the project.	2 hours 4 hours 2 hours 3 hours 3 hours
8.4 Bibliography 1. A. Henrot, M. Pierre, Shape Variation and Optimization - A geometric analysis, EMS Press, 2018 2. G. Allaire, Conception optimale des structures, Springer, 2007 3. B. Bogosel - course support and applications - SUMS Platform.		
8.5 Laboratory	**Teaching methods**	**Observations**
-	-	-
8.6 Bibliography -		
8.7 Project	**Teaching methods**	**Observations**
-	-	-
8.8 Bibliography -		

* course and seminar/laboratory assignments must fully cover the specific objectives formulated in section 7.2.
* the topics addressed in the course and those in the seminar can be designed both in a complementary relationship and/or in a deeper understanding of the topic.
* it is advisable that the development of the subject sheet be done as a team by the course and seminar/laboratory lecturers, possibly by all lecturers of the same subject, where several people teach the same subject.

9. Correlating the content of the discipline with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program

The content of the discipline is consistent with what is done in other university centers in the country and abroad.

10. Evaluation

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade

10.1 Course	- correctness and completeness of knowledge; - logical coherence; - degree of assimilation of specialized language; - conscientiousness, interest in individual study.	Final exam/Project	80%
10.2 Seminar	- the ability to operate with the acquired knowledge; - the ability to apply it in practice; - conscientiousness, interest in individual and team study.	Active participation in seminars	20%
10.3 Laboratory	-	-	-
10.4 Project	-	-	-
10.5 Minimum performance standard Knowledge of the fundamental elements of theory, solving a simple application.			

11. Learning outcomes

The graduate correctly explains and interprets mathematical concepts, using specific language. The graduate is able to abstract, formalize and generalize mathematical material. The graduate knows and applies appropriate methods and techniques for solving problems in algebra, geometry, mathematical analysis, functional analysis, linear programming, differential equations, statistics, etc.

Date of completion	**Signature of the course holder**	**Signature of the seminar holder**
2025-10-08 23:49:16		
Date of approval in the department	**Signature of the department director**	

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Annex to the Course Sheet (optional)

ANNEX TO THE DISCIPLINE SHEET

12. Evaluation - grade increase

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade
12.1 Course	-	-	-
12.2 Seminar	-	-	-
12.3 Laboratory	-	-	-
12.4 Project	-	-	-
12.5 Minimum performance standard -			
Participation in 50% of teaching activities and mastery of basic concepts.*			
Date of completion		Signature of the course holder	Signature of the seminar holder
2025-10-08 23:49:16			

13. Evaluation - arrears

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade
13.1 Course	-	-	-
13.2 Seminar	-	-	-
13.3 Laboratory	-	-	-
13.4 Project	-	-	-
13.5 Minimum performance standard -			
Participation in 50% of teaching activities and mastery of basic concepts.*, **			
Date of completion		Signature of the course holder	Signature of the seminar holder
2025-10-08 23:49:16			

* Indicative wording
* * If the discipline has laboratory hours, the methods for recovering them must be provided.

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SYLLABUS

1. Study Programme

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Program studied	**Mathematical modeling in science and technology**
1.8. Form of education	**Full – Time Study**

2. Course Details

2.1. Name of the discipline	**GmET2O06 Specialized practice**
2.2. Education Plan Holder	**Prof. Dr. Stoica Codruta Simona**
2.3. Assistant	**Prof. Dr. Stoica Codruta Simona**
2.4. Year of study	1
2.5. Semester	2
2.6. Type of evaluation	**C**
2.7. Discipline regime	**DT**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	8
3.2. Class hours per week	0
3.3. Seminar/laboratory/project hours per week	8
3.4. Total hours in the curriculum	112
3.5. Course hours per semester	0
3.6. Seminar/laboratory/project hours per semester	112
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	0
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	0
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	0
3.4.4. Tutoring	0
3.4.5. Examinations	0

3.4.6. Other activities ...	0
3.7. Total hours of individual study	0
3.8. Total hours per semester	**112**
3.9. Number of credits	3

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	
4.2. Competence prerequisites	

5. Necessary conditions (where applicable)

5.1. Conditions for conducting the COURSE	
5.2. Conditions for conducting the Seminary	
5.3. Conditions for conducting the laboratory	
5.4. Conditions for conducting the PROJECT	**Seminar room, properly equipped with a whiteboard and video projector, internet connection**

6. Specific skills acquired (where applicable)

6.1. Professional skills	
6.2. Transversal skills	**CT2. Approach challenges positively** **CT5. Works in teams**

7. Discipline objectives (where applicable)

7.1. General objective of COURSE	**- Initiating the student in scientific research methods** **- The student should develop the ability to correctly apply the skills and the accumulated knowledge**
7.2. Specific objectives	**-Presentation of results obtained in a research field chosen from mathematics** **- Writing reports on a given topic** **- Learning scientific research and writing skills scientific papers**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
8.2 Course Bibliography		
8.3 Seminar Content	Teaching methods	Observations
8.4 Seminar Bibliography		
8.5 Laboratory Content	Teaching methods	Observations
8.6 Laboratory Bibliography		
8.7 Project Content	Teaching methods	Observations
1. RESEARCH PREMISES a. Motivation for the topic research b. Personal characteristics c. Resources available and accessible	lecture participatory, the debate, exposure	2 ore
2. TECHNICAL REQUIREMENTS FOR WRITING PROJECT a. Size b. Drafting c.	lecture participatory,	2 ore

Following the rules of academic writing	debate, exposition	
3. WHAT THE PROJECT MUST CONTAIN I A. Steps preceding the writing of the research project 1) Choosing a topic – What am I researching? a. Selecting the field. b. Formulating the topic c. Project title. 2) Delimitation of the study area. a. Temporal delimitation b. Spatial delimitation c. Narrowing the actual field of investigation. d. Narrowing the scope of the research to a defined number of units of analysis 3) Project title.	Participatory lecture, debate, presentation	6 ore
4. WHAT THE PROJECT II B MUST CONTAIN. Structure of a research project 1) Introduction a) Study problem statement b) Objective(s) of the research project c) Significance of the study d) Research questions 2) Relevant literature 3) Research methodology a) Research procedure. Methods chosen b) Research instruments. c) Expected results 4) Conclusions 5) Bibliography	Participatory lecture, debate, exposure	6 ore
5. Research project templates	Participatory lecture, debate, exposure	12 ore

8.8 Project Bibliography

1. B. Buchberger, Thinking, Speaking, Writing, http://www.risc.jku.at/people/buchberger/thinking_course.html 2. P.Edwards: How to give an academic talk, http://pne.people.si.umich.edu/PDF/howtotalk.pdf 3. Hirsch, An index to quantify an individual's scientific research output, http://www.pnas.org/content/102/46/16569.full 4. The Clarivate Analytics Impact Factor, https://clarivate.com/essays/ impact-factor/ 5. R.Kitchin & D. Fuller, The Academic' Guide to Publishing, SAGE Publications, London, 2005.

6. H.F. Moed, Citation Analysis in Research Evaluation, Springer, 2005.

7. M.A.Nielsen, Principles of Effective Research, http://michaelnielsen.org/blog/principles-of-effective-research/ 8. University ranking, http://www.topuniversities.com/university-ranking-articles/ 9. J.Radel, Oral Presentations, http:// people.eku.edu/ritchisong/oralpres.html 10. C. Stoica, Project Support, SUMS, 2025

9. Corroboration/validation of the course contents (where applicable)

The content of the discipline is consistent with what is done in other university centers in the country and abroad. For a better adaptation of the content of the discipline to the requirements of the labor market, meetings were held with both representatives of the business environment and with mathematics and computer science teachers from pre-university education.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight from the final grade
10.1. Course			
10.2. Seminar			
10.3. Laboratory			
10.4. Design	**- correctness and completeness of knowledge; - logical coherence; - degree of assimilation of specialized language; - conscientiousness, interest in individual study. - the ability to operate with the acquired knowledge; - the ability to apply it in practice;**	Oral evaluation (final in the exam session): - Student's free presentation; - Evaluation conversation; Oral questionnaire. Active participation in courses. Oral assessment (final exam period): - project completion necessary - homework	30% 20% 30% 20%

10.5 Minimum performance standard

The student must demonstrate that he or she is able to document and produce a scientific paper.

11. Learning outcomes

The graduate: a) Knows the concepts and theories related to resilience, emotional intelligence and positive thinking, applicable in professional and personal contexts. b) Understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies. c) Knows models of positive leadership and change management, relevant for constructively addressing challenges in teams and organiza
The graduate: a) Identifies and analyzes challenges objectively, maintaining a balanced and solution-oriented attitude. b) Applies emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively. c) Transforms obstacles into opportunities for learning and development, demonstrating cognitive flexibility and openness to change. d) Encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate.
The graduate: a) Takes responsibility for his/her own reactions to challenges, demonstrating emotional maturity and professionalism. b) Makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective. c) Acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture. d) Promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment. The graduate: a) Knows the concepts and theories related to resilience, emotional intelligence and positive thinking, applicable in professional and personal contexts. b) Understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies. c) Knows models of positive leadership and change management, relevant for constructively addressing challenges in teams and organizations. The graduate: a) Identify and analyze challenges objectively, maintaining a balanced and solution-oriented attitude. b) Apply emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively. c) Transform obstacles into opportunities for learning and development, demonstrating cognitive flexibility and openness to change. d) Encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate. The graduate: a) Takes responsibility for their own reactions to challenges, demonstrating emotional maturity and professionalism. b) Makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective. c) Acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture. d) Promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment. The graduate: a) Knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research and decision-making. b) Understands the impact of minor errors on final results, in contexts such as data analysis, scientific writing, project management or professional communi
Identifies inconsistencies, errors or omissions in documents, data or processes b) Applies review and verification techniques to ensure the accuracy and coherence of information. c) Complies with formatting, structuring and presentation standards in writing texts, reports or scientific papers. d) Monitors details in complex activities, without losing sight of the overall objectives of the project. rigor and professionalism in delivering results. b) Works autonomously with a high level of attention to detail, even under pressure or deadlines. c) Contributes to maintaining quality standards in the team, providing constructive feedback and supporting quality control processes. d) Demonstrates consistency and discipline in verification and validation activities, contributing to reducing risks and increasing efficiency. The graduate: a) Takes responsibility for the accuracy of his/her own work, rigor and professionalism in delivering results. b) Works autonomously with a high level of attention to detail, even under pressure or deadlines. c) Contributes to maintaining quality standards within the team by providing constructive feedback and supporting quality control processes. d) Demonstrates consistency and discipline in verification and validation activities, contributing to reducing risks and increasing efficiency.

Course Coordinator
Prof. Stoica Codruța Simona, PhD

Seminar Coordinator
Prof. Stoica Codruța Simona, PhD

Head of the Department
Assoc. Prof. Lorena Camelia Popa, PhD

DEAN
Prof. Sorin-Florin NĂDĂBAN, PhD

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SYLLABUS

1. Study programme

1.1. Higher education institution	**„Aurel Vlaicu" University of Arad**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics and Computer Science**
1.4. Field of study	**Mathematics**
1.5. Study level	**2025-2026**
1.6. Ciclul de studii	**Master**
1.7. Study programme / Qualification	**Modelare matematică în știință și tehnologie**
1.8. Form of education	**Full – Time study**

2. Course details

2.1. Name of the course	**Data Science**
2.2. Course coordinator	**Dragoi Vlad-Florin**
2.3. Seminar/laboratory/project coordinator	**Dragoi Vlad-Florin**
2.4. Study year	**2**
2.5. Semester	**1**
2.6. Evaluation type	**Exam**
2.7. Course type	**Mandatory**

3. Estimated total time (hours per semester)

3.1. Hours per week	**3**
3.2. Lecture hours per week	**1**
3.3. Seminar/laboratory/project hours per week	**2**
3.4. Total hours per curriculum	**42**
3.5. Lecture hours per semester	**14**
3.6. Seminar/laboratory/project hours per semester	**28**
	Time division [hrs]
3.4.1. Independent study from textbooks, course support, bibliography and notes	**40**
3.4.2. Additional reading (libraries, specialized electronic platforms and field research)	**40**
3.4.3. Preparing of seminars/laboratories/projects, homework, papers, portfolios and essays	**24**
3.4.4. Tutorial coaching	**2**
3.4.5. Examinations	**2**
3.4.6. Other activities	
3.7. Total individual study hours	**108**
3.8. Total hours per semester	**150**
3.9. Number of ECTS credits	**6**

4. Prerequisites (if applicable)

4.1. Curriculum related	Probability, Statistics, Algorithms
4.2. Competence related	Programming (Python, R)

5. Conditions (if applicable)

5.1. for the lecture	**Laptop/Computer, projector, software**

5.2. for the seminar	
5.3. for the laboratory	**Computers with Internet connection, and instaled software (R, python)**
5.4. for the project	

6. Specific educational objectives (competences to be acquired)

6.1. Competenţe profesionale	**C1. Performs analytical mathematical calculations** **C2. Synthesizes information** **C3. Thinks abstractly** **C4. Communicates mathematical information** **C5. Studies relationships between quantities** **C6. Uses data processing techniques** **C7. Apply statistical analysis techniques** **C8. Performs data analysis** **C9. Identify statistical patterns** **C10. Apply scientific methods** **C12. Apply the principles of ethics and scientific integrity in research activities**
6.2. Competenţe transversale	**CT1. Thinks analytically** **CT2. Approaches challenges positively** **CT3. Pays attention to details** **CT4. Works efficiently** **CT5. Works in teams**

7. Course outcomes (resulting from the specific educational objectives to be acquired)

7.1. General outcomes	**The general outcome ist o familiarize the students with the various tehcniques of data analysis, from a theoretical point of view as well as a practical point of view.**
7.2. Specific outcomes	

8. Outline (if applicable)

8.1 Lecture Outline	Teaching methods	Remarks
1. Introduction 2.1 Data vizualisation 2.2 Data processing 2.3 EDA 3. Preparing data 3.1 Importul de date, salvarea, exportarea 3.2 Special types 3.3 Databases 3.4 Strings: REGEX and patterns 3.5 Temporal sequentials 4. Modelisation 4.1 Introduction 4.2Linear models: regression 4.2 Classification 4.3Tree-type structures: Random forest 5. Comunications		

8.2 Lecture References

1. **Garrett Grolemund, Hadley Wickham, R for Data Science, 2016, O'Reilly Media, Inc.**
2. **Garrett Grolemund, Hadley Wickham, Hands-On Programming with R, 2014, O'Reilly Media, Inc.**
3. **Radislav Vaisman, Zdravko I. Botev, Dirk P. Kroese, Thomas Taimre, Data Science and Machine Learning: Mathematical and Statistical Methods, 2019, Chapman & Hall/Crc Machine Learning & Pattern Recognition.**

8.3 Seminar Outline	Teaching methods	Remarks

8.4 Seminar References

8.5 Laboratory Outline	Teaching methods	Remarks
1 Data vizualization: plot,, scatterplot, histograms, etc. 2. Preparing data: rezidus, missing data, sorting, sequencing 3. Import data, save data, exporting, formating, Databases 4 Regresions: liniar, multivariate, logistic, etc. 5 Classification: nearest neibour, random forest, etc. 5. Comunication		

8.6 Laboratory References

1. **Garrett Grolemund, Hadley Wickham, R for Data Science, 2016, O'Reilly Media, Inc.**
2. **Garrett Grolemund, Hadley Wickham, Hands-On Programming with R, 2014, O'Reilly Media, Inc.**

3. Radislav Vaisman, Zdravko I. Botev, Dirk P. Kroese, Thomas Taimre, Data Science and Machine Learning: Mathematical and Statistical Methods, 2019, Chapman & Hall/Crc Machine Learning & Pattern Recognition.

8.7 Project Outline	Teaching methods	Remarks

8.8 Project References

9. Correlation of course outline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

10. Evaluation / Grading (if applicable)

Activity type	Evaluation criteria	Evaluation methods	Percentage of the final grade
10.1. Lecture	Level of mastering the domain-specific vocabulary Logical consistency Extent of correctness and completeness of knowledge Responsibility Commitment	Final written exam at the end of the semester Active participation	50%
10.2. Seminar			
10.3. Laboratory	Ability to use the knowledge Ability to apply theoretical knowledge to practical cases Responsibility Commitment	Partial written exam during the semester Independent work, homework Active participating	50%
10.4. Project			
10.5 Minimal performance standard **Proper mastering of the basics, understanding the fundamental notions/concepts, fluent with the domain-specific vocabulary, and able to analyze and explain simple cases.**			

11. Learning outcomes

Knowledge:

The graduate documents himself/herself in relation to a given topic.
The graduate knows ways of collecting, classifying and evaluating information from various sources.
The graduate critically summarizes new and complex information in relation to a given topic.
The graduate defines concepts and understands the fundamental concepts underlying abstract thinking: axioms, theorems, proofs, structures, functions, relations, abstract data types
The graduate knows the principles of mathematical and formal logic
The graduate formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples.
The graduate knows advanced mathematical terminology, in Romanian and English.
The graduate knows the conventions of notation, symbolization and formal presentation of mathematical content.
The graduate translates various practical problems into mathematical language.
The graduate is able to express mathematical problems/theorems with practical implications in ordinary language.
The graduate knows advanced methodologies for modeling and verifying relationships between quantities.
The graduate knows methods and techniques for collecting, processing and analyzing data.
The graduate demonstrates advanced knowledge of the fundamental concepts and modern methods of statistical analysis, including descriptive, inferential statistics, regression, analysis of variance and multivariate models.
The graduate understands the theoretical principles underlying statistical methods, including their assumptions, limitations and applicability conditions.
The graduate integrates statistical knowledge with the foundations of scientific research and data analysis, in interdisciplinary and applied contexts.
The graduate demonstrates advanced knowledge of the data life cycle, from collection and cleaning to interpretation and reporting.
The graduate understands the theoretical foundations of building and validating statistical models, as well as the assumptions and limitations associated with each type of model.
The graduate knows the criteria for selecting models (e.g. AIC, BIC, R^2 adjustment, cross-validation) and their impact on the interpretation of results.
The graduate demonstrates advanced knowledge of the concepts and models of analytical thinking, including logical reasoning, causal analysis, critical evaluation of information and evidence-based decision-making.
The graduate understands methods for structuring complex problems, such as SWOT analysis, decision analysis, logic modeling and systemic approaches.
The graduate knows techniques for assessing the validity and coherence of arguments, in academic and professional contexts.
The graduate understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies.
The graduate knows models of positive leadership and change management, relevant for constructively addressing challenges in teams and organizations.
The graduate knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research and decision-making.

Skills:

The graduate uses various computing technologies to perform analytical mathematical calculations and determine solutions to a problem in the field.
The graduate classifies the information available to him/her according to the context.
The graduate provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the subjects in the curriculum.
The graduate interprets and explains graphs, tables, mathematical models, numerical or symbolic results.
Can examine and interpret relationships between variables in advanced mathematical, economic, scientific or social problems
Can use statistical, mathematical or computational techniques to build and validate models involving relationships between variables.
Can formulate and test hypotheses related to qua The graduate can write reports, presentations or scientific publications that highlight and interpret the relationships between variables.
The graduate collects, processes and analyzes relevant data and information.
The graduate applies statistical methods for description, estimation and hypothesis testing,
The graduate creates relevant graphic visualizations to support the interpretation of data. Selects and applies appropriate statistical methods depending on the nature of the data and the objectives of the research.
Uses specialized IT tools to perform complex statistical analyses.
Critically interprets statistical results, formulating relevant conclusions
Visualize and communicate results effectively, adapting their presentation to the target audience.
The graduate applies estimation and validation techniques for models, using specialized software tools.
The graduate interprets the parameters and performance of statistical models, formulating rigorous and data-supported conclusions.
Compares and selects alternative models, justifying the choice based on statistical criteria and the application context.
The graduate formulates rational and well-argued solutions, based on data, facts, and logical principles.
The graduate encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate.

Responsibility and autonomy:

The graduate verifies and validates the results obtained through critical analysis.
The graduate assumes responsibility for choosing the correct calculation methods.
The graduate applies effective working techniques in multidisciplinary teams.
The graduate can work autonomously or in multidisciplinary teams.
The graduate finds solutions to practical, operational or conceptual problems in a wide range of contexts. He/she assumes responsibility for the validity and accuracy of the interpretation of data and identified relationships.
Interprets and communicates the results of data processing responsibly.
Plans and autonomously conducts statistical analysis processes, assuming responsibility for the correctness and relevance of the results.
Critically evaluates the quality of data and the validity of the methods used, respecting scientific and ethical standards.
Makes independent decisions regarding the selection of statistical techniques and the interpretation of results in complex contexts.
Plans and autonomously manages data analysis processes, from defining analytical questions to communicating results.
Critically evaluates the quality of data and the validity of the methods used, assuming responsibility for the rigor and ethics of the analytical process.

Promotes the responsible use of statistical modeling, respecting ethical principles and good practices in research and analysis. Analyzes and interprets the results of scientific research carried out responsibly. Assumes responsibility for the quality of the analysis process, demonstrating rigor, objectivity and coherence in reasoning. Makes autonomous decisions in complex situations, based on a critical assessment of alternatives and consequences. Promotes analytical thinking in teams and organizations, contributing to the development of a culture of reflection and informed decision-making

Course coordinator	Seminar/laboratory/project coordinator	Head of the Department	Dean
Dragoi Vlad-Florin	Dragoi Vlad-Florin	Lect.univ.dr. Lorena Camelia POPA	Prof.univ.dr. Sorin-Florin NĂDĂBAN

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Operator de date cu caracter personal nr.2929

SYLLABUS

1. Study programme

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Full-time education**

2. Course details

2.1. Name of the discipline	**GmEA2O08 Convex analysis**
2.2. Education Plan Holder	**Prof. Dr. Moț Ghiocel**
2.3. Assistant	**Prof. Dr. Moț Ghiocel**
2.4. Year of study	**1**
2.5. Semester	**2**
2.6. Type of evaluation	**SE**
2.7. Discipline regime	**Compulsory**

3. Estimated total time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**
3.2. Class hours per week	**2**
3.3. Seminar/laboratory/project hours per week	**1**
3.4. Total hours in the curriculum	**42**
3.5. Course hours per semester	**28**
3.6. Seminar/laboratory/project hours per semester	**14**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**35**
3.4.2. Additional documentation in the library, on specialized electronic platforms and on land	**35**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**30**
3.4.4. Tutoring	**4**
3.4.5. Examinations	**4**
3.4.6. Other activities ...	**0**
3.7. Total hours of individual study	**108**
3.8. Total hours per semester	**150**
3.9. Number of credits	**6**

4. **Preconditions** (where applicable)

4.1. Curriculum prerequisites	
4.2. Competence prerequisites	

5. **Necessary conditions** (where applicable)

5.1. Course conditions	**Whiteboard** **Video projector, Internet connection**
5.2. Conditions for holding the seminar	**Whiteboard** **Computer/Laptop, Internet connection**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. **Specific skills acquired** (where applicable)

6.1. Professional skills	**C2. Synthesize information.** **C3. Thinks abstractly.** **C4. Communicates mathematical information.** **C5. Study relationships between quantities.** **C10. Apply scientific methods.**
6.2. Transversal skills	**CT1. Think analytically.** **CT2. Approach challenges positively.** **CT3. He pays attention to details.** **CT4. Works efficiently.**

7. **Discipline objectives** (where applicable)

7.1. General objective of the discipline	**- The student should know the basic concepts of convex analysis and understand important theorems.** **- The student develops the skills to correctly apply the acquired knowledge to solve different classes of problems.** **- The student must form and develop the ability to think and analyze problems.**
7.2. Objectives specific	**- The student is able to demonstrate that he has acquired sufficient knowledge** **• recognize the objects of convex analysis: convex sets, convex functions, convex optimization problems; • describe the objects of study of the discipline; • define and explain the basic concepts of convex analysis; • formulate the basic principles and results of convex analysis; • interpret the extreme problem as a mathematical model of a real decision-making problem (choosing the optimal variant); • define the notion of a solution to the extreme problem (local or global optimum); • classify problems of an unconditional or conditional extreme nature according to the properties of their components; • formulate and interpret geometric conditions, principles and optimality criteria for various classes of extreme problems; • solve extreme problems with analytical methods; • algorithmically concretize the ideas underlying the numerical methods for solving the main classes of extreme problems.** **- The student is able to correctly apply the basic methods and principles in solving complex problems** **• explain the essence, appropriateness and importance of the basic concepts studied in the discipline; • explain the principle of duality; • translate a real problem from the usual language of the specific field (economics, technology, computer science, etc.) into the language of extreme problems (objective function, restrictions, acceptable solutions, local and global optimal solutions, etc.); • explain the ideas behind the classical methods for solving extreme problem and their implementation in the form of concrete algorithms; • use theoretical knowledge to solve simple analytical problems in the basic calculations of the theory of mathematical optimization: linear programming, convex programming, nonlinear programming; • select an appropriate method for solving an extremely local or global problem, argue the appropriateness of selecting the method, implement the numerical method in the form of algorithms and computer programs.** **- The student is able to recognize the main classes/types of problems: • to investigate extreme problems that have not been studied in the course, to define for them the correct concepts of solution, to build criteria and principles of optimality and to prove their correctness;**

	• solves extreme problems in concrete areas of human activity by analytical and numerical methods; • can convert a non-convex optimization problem into a convex optimization when such a transformation is possible; • to interpret the solution of a real problem from a practical point of view and to develop recommendations for decision-makers; • to adapt, improve and develop the knowledge and skills acquired within the given discipline and in other disciplines: calculus of variation and optimal control, operations research, mathematical modeling, econometrics, computer programming, etc. • to solve the solitaire of theoretical and practical skills. - The student can design projects for the mathematical modeling of a concrete problem.

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. Preliminaries 1.1. Affine sets 1.2. Convex sets 1.3. Cones 1.4. Properties 1.5. Algebra of convex sets 1.6. Separation theorems	Lecture, debate, demonstration, exemplification	8 hours
2. Convex functions 2.1. Properties 2.2. Operations with convex functions 2.3. Convexity criteria of differentiable functions 2.4. Extremal properties of convex functions on convex sets 2.5. Convex optimization problems	Lecture, debate, demonstration, exemplification	6 hours
3. Convex Programming Problem 3.1. Differentiation 3.2. Gradient 3.3. Derivatives by Direction 3.4. Subgradient 3.5. Subdifferential 3.6. Properties 3.7. Optimality Conditions	Lecture, debate, demonstration, exemplification	8 hours
4. Convex structures 4.1. Convex structures in the sense of Gudder 4.2. Convex structures in the Takahashi direction 4.3. Convex structures in the Michael sense	Lecture, debate, demonstration, exemplification	6 hours

8.2 Course Bibliography

1. **BERTSEKAS, D.P., NEDIC, A., OZDAGLAR, A.E., Convex Analysis and Optimization, Athena Scientific, 2003.**
2. **BRECKNER, BE, POPOVICI, N., Convexity and Optimization. An Introduction, EFES, Cluj-Napoca, 2006.**
3. **BRECKNER, BE, POPOVICI, N., Problems of operational research, EFES, Cluj-Napoca, 2006 (in Romanian).**
4. **KRANTZ, S. G., Convex Analysis, CRC Press, 2014, 176 pag.**
5. **LUPSA, L., Numerical optimization methods. Special issues in discrete optimization, Cluj-Napoca: Risoprint, 2005.**
6. **MOȚ, G., Types of convexity in modern mathematics. Applications of the Theory of Altitude, Ed. Mirton, 1999, 193 pages.**
7. **MOȚ, G., Convexity and Allure in Elena Popoviciu'sense, Miracle Printers Publishing House, Vancouver, Washigton, USA., 2004, ISBN: 973-578-447-6, 106 pag.**
8. **MOȚ, G., PETRUȘEL, A., PETRUȘEL, G., Topics in Nonlinear Analysis and Applications to Mathematical Economics, House of the Book of Science, 2006, 153 pag., ISBN 973-686-952-0**
9. **9. MOȚ, G., Seminar and course notes-Convex Analysis, 2025.**
10. **NOCEDAL, J., WRIGHT, S.J., Numerical Optimization, Second Edition, New York: Springer, 2006.**
11. **PETRUȘEL, A., MOȚ, G., Multivalued analysis, convexity and mathematical economics, House of the Book of Science, 2003, ISBN: 973-578-900-3, 166 pag.**
12. **VANDERBEI, R. J., Linear Programming. Foundations and extensions, International Series in Operations Research & Management Science 37, Kluwer Academic Publishers, Boston, 2001.**
13. **WEBSTER, R., Convexity, Oxford University Press, New York, 1994.**

8.3 Seminar Content	Teaching methods	Observations
1. Preliminaries 1.1. Affine sets 1.2. Convex sets 1.3. Cones 1.4. Properties 1.5. Algebra of convex sets 1.6. Separation theorems	Exercise, discussion and debate, modeling, project	4 hours
2. Convex functions 2.1. Properties 2.2. Operations with convex functions 2.3. Convexity criteria of differentiable functions 2.4. Extremal properties of convex functions on convex sets 2.5. Convex optimization problems	Exercise, discussion and debate, modeling, project	3 hours
3. Convex Programming Problem 3.1. Differentiation 3.2. Gradient 3.3. Derivatives by Direction 3.4. Subgradient 3.5. Subdifferential 3.6. Properties 3.7. Optimality Conditions	Exercise, discussion and debate, modeling, project	4 hours
4. Convex structures 4.1. Convex structures in the sense of Gudder 4.2. Convex structures in the Takahashi direction 4.3. Convex structures in the Michael sense	Exercise, discussion and debate, modeling, project	3 hours

8.4 Seminar Bibliography

1. **BERTSEKAS, D.P., NEDIC, A., OZDAGLAR, A.E., Convex Analysis and Optimization, Athena Scientific, 2003.**
2. **BRECKNER, BE, POPOVICI, N., Convexity and Optimization. An Introduction, EFES, Cluj-Napoca, 2006.**
3. **BRECKNER, BE, POPOVICI, N., Problems of operational research, EFES, Cluj-Napoca, 2006 (in Romanian).**
4. **KRANTZ, S. G., Convex Analysis, CRC Press, 2014, 176 pag.**

5. LUPSA, L., Numerical optimization methods. Special issues in discrete optimization, Cluj-Napoca: Risoprint, 2005.
6. MOȚ, G., Types of convexity in modern mathematics. Applications of the Theory of Altitude, Ed. Mirton, 1999, 193 pages.
7. MOȚ, G., Convexity and Allure in Elena Popoviciu'sense, Miracle Printers Publishing House, Vancouver, Washigton, USA., 2004, ISBN: 973-578-447-6, 106 pag.
8. MOȚ, G., PETRUȘEL, A., PETRUȘEL, G., Topics in Nonlinear Analysis and Applications to Mathematical Economics, House of the Book of Science, 2006, 153 pag., ISBN 973-686-952-0
9. MOȚ, G., Seminar and course notes-Convex Analysis, 2025.
10. NOCEDAL, J., WRIGHT, S.J., Numerical Optimization, Second Edition, New York: Springer, 2006.
11. PETRUȘEL, A., MOȚ, G., Multivalued analysis, convexity and mathematical economics, House of the Book of Science, 2003, ISBN: 973-578-900-3, 166 pag.
12. VANDERBEI, R. J., Linear Programming. Foundations and extensions, International Series in Operations Research & Management Science 37, Kluwer Academic Publishers, Boston, 2001.
13. WEBSTER, R., Convexity, Oxford University Press, New York, 1994.

8.5 Laboratory Content	Teaching methods	Observations
8.6 Laboratory Bibliography		
8.7 Project Content	Teaching methods	Observations
8.8 Project Bibliography		

9. Corroboration/validation of the course contents (where applicable)

This course is taught in similar programs at several universities, both in the country and abroad. In order to better match the demands of the labor market, meetings were organized with representatives of employers and with specialized teachers from the pre-university education system. The use of English brings and adds value to the program, allowing the employment of graduates by multinational companies (both from abroad and from Romania).

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade
10.1. Course	**knowledge; logical coherence; acquisition of specialized language; criteria targeting attitudinal aspects: seriousness, conscientiousness, interest in the topic addressed.**	Oral assessment: presentation of a final project, free presentation, oral questions. Active participation in the course	40% 10%
10.2. Seminar	**the ability to operate with the acquired knowledge; the ability to apply it in practice; conscientiousness and interest in study.**	Oral assessment: preparation and presentation of the final project. Active participation in seminars	40% 10%
10.3. Laboratory			
10.4. Project			
10.5 Minimum performance standard **Learning basic concepts, using specialized language, making a simple application.**			

11. Learning outcomes

Knowledge: The graduate: - documents himself/herself in relation to a given topic; - knows ways to collect, classify and evaluate information from various sources; - critically summarizes new and complex information in relation to a given topic; - defines concepts Understands the fundamental concepts underlying abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types; - knows the principles of mathematical and formal logic, as well as demonstration methods; - formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples; - knows advanced mathematical terminology, in Romanian and English; - knows the conventions of notation, symbolization and formal presentation of mathematical content; - translates various practical problems into mathematical language; - is able to express mathematical problems/theorems with practical implications in everyday language; - has the ability to analyze and interpret complex relationships between quantities in interdisciplinary contexts; -knows advanced methodologies for modeling and verifying relationships between quantities; - can develop and evaluate hypotheses based on relationships between quantities in scientific research; -has the ability to communicate and argue relationships between quantities in a clear and academic way; -constructively approaches scientific texts on a given topic; -selects and organizes the information necessary to carry out research; -compares and distinguishes related notions and their properties from advanced mathematical disciplines; -knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing a method, experimenting, analyzing the results, validating or rejecting the hypothesis; -demonstrates advanced knowledge of the concepts and models of analytical thinking, including logical reasoning, causal analysis, critical evaluation of information and evidence-based decision-making; -understands methods for structuring complex problems, such as analysis SWOT, decision analysis, logic modeling and systemic approaches; -knows techniques for assessing validity and coherence

arguments, in academic and professional contexts; -knows the concepts and theories related to resilience, emotional intelligence and positive thinking, applicable in professional and personal contexts; -understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies; -knows models of positive leadership and change management, relevant for constructively addressing challenges in teams and organizations; -knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research and decision-making; -understands the impact of minor errors on the final results, in contexts such as data analysis, scientific writing, project management or professional communication; -knows methods and techniques for quality verification and control, applicable in various fields of activity; -knows principles and methods of efficient organization of activity, including planning, prioritizing tasks and time management; -understands the concepts of personal productivity and professional performance, in individual and team contexts; -knows digital tools and modern activity management techniques, useful for optimizing work processes.

Skills: The graduate: - correctly interprets the information collected on a given topic; - classifies the information available according to the context; - selects the information necessary to solve a specific problem; - uses digital tools to support information synthesis; - provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the curriculum disciplines; - represents and formulates concepts and problems in abstract, symbolic or formal terms; - creates abstract representations for computer structures: trees, graphs, recursive functions, object classes; - writes rigorous demonstrations, logical arguments and detailed explanations, using specific language; - develops the solution to a problem in the field using appropriate symbols, language and mathematical tools; - interprets and explains graphs, tables, mathematical models, numerical or symbolic results; - can examine and interpret relationships between variables in advanced mathematical, economic, scientific or social problems; -can use statistical, mathematical or computational techniques to build and validate models involving relationships between variables; -can formulate and test hypotheses related to quantitative relationships within research projects; -can write reports, presentations or scientific publications that highlight and interpret relationships between variables; -apply scientific methods and techniques to investigate current phenomena or practical problems; -correct and integrate previous knowledge into current studies; -use digital technology in the studies undertaken; -recognize and analyze the necessary and/or sufficient conditions from the statement of mathematical assertions and specify their role in the demonstration; -analyze complex problems by breaking them down into essential components, identifying causal relationships and relevant factors; -critically evaluate information and arguments, identifying reasoning errors, cognitive biases and sources of uncertainty; -formulate rational and well-argued solutions, based on data, facts and logical principles; -applies analytical methods in decision-making, in interdisciplinary contexts and under conditions of uncertainty; -identifies and analyzes challenges objectively, maintaining a balanced and solution-oriented attitude; -applies emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively; -transforms obstacles into learning and development opportunities, demonstrating cognitive flexibility and openness to change; -encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate; -identifies inconsistencies, errors or omissions in documents, data or processes, demonstrating a rigorous and systematic approach; -applies review and verification techniques to ensure the correctness and coherence of information; -respects formatting, structuring and presentation standards in writing texts, reports or scientific papers; -monitors details in complex activities, without losing sight of the overall objectives of the project; -plans and structures activities effectively, establishing clear objectives, realistic deadlines and adequate resources; -manages time and workload, adapting to priorities and deadlines without compromising quality; -uses agile or traditional tools and working methods to increase efficiency in individual or collaborative projects; -monitors progress and optimizes work processes, identifying and eliminating bottlenecks or waste of time resources.

Responsibility and autonomy: The graduate: - uses the information at his disposal coherently; - demonstrates professionalism in managing the information at his disposal; - can work autonomously or in multidisciplinary teams; - demonstrates intellectual autonomy in exploring and manipulating abstract concepts; - finds solutions to practical, operational or conceptual problems, in a wide range of contexts; - generates argumentative procedures in support of solutions; - communicates and interprets the solution to a problem; - compares alternative solutions using specific mathematical language; - presents ideas and processes using appropriate mathematical symbols, language and tools; - demonstrates rigor and intellectual discipline in writing and presenting his own mathematical results; - assumes responsibility for the validity and accuracy of the interpretation of the data and relationships identified; - takes the freedom to choose techniques and tools relevant to the specifics of the problem, assuming responsibility for the results obtained; -autonomously manages the research process, ensuring scientific rigor and academic integrity; -assumes responsibility for presenting and explaining conclusions clearly and in a well-argued manner, assuming independence in writing and supporting scientific papers; -writes, edits and presents scientific texts; -assumes responsibility for the correctness, coherence and clarity of the information presented; -responsibly analyzes and interprets the results of the scientific research carried out; -adapts techniques and strategies for solving routine problems to solving synthesis problems and problems of higher complexity; -assumes responsibility for the quality of the analysis process, demonstrating rigor, objectivity and coherence in reasoning; -makes autonomous decisions in complex situations, based on a critical assessment of alternatives and consequences; -promotes analytical thinking in teams and organizations, contributing to the development of a culture of reflection and informed decision-making; -demonstrates initiative in applying analytical thinking to solve real problems, in academic, professional or social contexts; -takes responsibility for his/her own reactions to challenges, demonstrating emotional maturity and professionalism; -makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective; -acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture; -promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment; -takes responsibility for the accuracy of his/her own work, demonstrating rigor and professionalism in delivering results; -works autonomously with a high level of attention to detail, even under pressure or deadlines; -contributes to maintaining quality standards in the team, providing constructive feedback and supporting quality control processes; -demonstrates consistency and discipline in verification and validation activities, contributing to reducing risks and increasing efficiency; -assumes responsibility for achieving the set objectives, demonstrating consistency and results orientation; -works autonomously and efficiently in complex contexts, maintaining a balance between quality, time and resources; -contributes to making the team's work more efficient, by proposing solutions and good organizational practices; -demonstrates initiative in continuously improving the way of working, adapting to changes and learning from experience.

Titular	Assistant	Head of the Department	DEAN
Prof. Dr. Moț Ghiocel	Prof. Dr. Moț Ghiocel	Conf.univ.dr. Lorena Camelia Popa	Prof. Sorin-Florin NĂDĂBAN, PhD

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Operator de date cu caracter personal nr.2929

SYLLABUS

1. Program data

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Full-time education (FT)**

2. Data about discipline

2.1. Name of the discipline	**GmEU2O09 Fuzzy logic and quantum logic**
2.2. Education Plan Holder	**Prof. Dr. Nădăban Sorin Florin**
2.3. Assistant	**Prof. Dr. Nădăban Sorin Florin**
2.4. Year of study	**1**
2.5. Semester	**2**
2.6. Type of evaluation	**ES**
2.7. Discipline regime	**OB**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**
3.2. Class hours per week	**2**
3.3. Seminar/laboratory/project hours per week	**1**
3.4. Total hours in the curriculum	**42**
3.5. Course hours per semester	**28**
3.6. Seminar/laboratory/project hours per semester	**14**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**108**
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	**0**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**0**
3.4.4. Tutoring	**0**
3.4.5. Examinations	**0**
3.4.6. Other activities ...	**0**
3.7. Total hours of individual study	**108**

3.8. Total hours per semester	**150**
3.9. Number of credits	**6**

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	**That's not the case**
4.2. Competence prerequisites	**That's not the case**

5. Necessary conditions (where applicable)

5.1. Course conditions	**That's not the case**
5.2. Conditions for holding the seminar	**That's not the case**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C3. Thinks abstractly** **C4.Communicates mathematical information** **C10. Applies scientific methods** **C2. Synthesizes information** **C5. Studies relationships between quantities**
6.2. Transversal skills	**CT1. Think analytically** **CT2. Approaches challenges positively** **CT3. Pays attention to details** **CT4. Works efficiently**

7. Discipline objectives (where applicable)

7.1. General objective of the discipline	**Students will gain advanced knowledge of fuzzy logic and quantum logic.**
7.2. Specific objectives	**Students have advanced knowledge of lattice theory, fuzzy logic, and quantum logic. Students can make various connections between fuzzy logic and quantum logic.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. Aristotelian Logic 2. Notions and concepts of fuzzy sets 3. Fuzzy numbers 4. Linguistic variables 5. Triangular norms 6. Fuzzy relations 7. Generalizations and extensions of fuzzy sets 8. Lattice theory; Boolean algebras; orthomodular lattices 9. Fuzzy logic 10. From quantum mechanics to quantum logic 11. Connections between fuzzy logic and quantum logic	Lecture Dialogue Exposure Problematization	

8.2 Course Bibliography

1. S. Nădăban, From Classical Logic to Fuzzy Logic and Quantum Logic: A General View, International Journal of Computers Communications & Control, 16(1), 2021.

2. S. Nădăban, Some fundamental properties of fuzzy linear relations between vector spaces, Filomat, 30(1) (2016), 41-53.

3. S. Nădăban, D. Deac (2023). Nonstandard Fuzzy Sets: A General View. In: Dzitac, S., Dzitac, D., Filip, F.G., Kacprzyk, J., Manolescu, MJ., Oros, H. (eds) Intelligent Methods Systems and Applications in Computing, Communications and Control. ICCCC 2022. Advances in Intelligent Systems and Computing, vol 1435. 208-218, Springer, Cham.

4. S. Nădăban, S. Dzitac, I. Dzitac, Fuzzy TOPSIS: A general view, Promoting Business Analytics ond Quantitative Management of Technology: 4th International Conference on Information Technology and Quantitative Management (ITQM 2014), Procedia Computer Science, 91 (2016), 823-831.

5. S. Nădăban, I. Dzitac, Special Types of Fuzzy Relations, Information Technology and Quantitative Management (ITQM 2014), Procedia Computer Science, 31C (2014), 552-557.

6. Zadeh, L.A. (1965). Fuzzy Sets. Information and Control, 8(3), 338–353.

7. Zadeh, L.A. (1975). The Concept of a Linguistic Variable and Its Application to Approximate Reasoning. Information Sciences, 8(3), 199–249.
8. Klir, G.J., & Yuan, B. (1995). Fuzzy Sets and Fuzzy Logic: Theory and Applications. Prentice Hall.
9. Pedrycz, W., & Gomide, F. (2007). Fuzzy Systems Engineering: Toward Human-Centric Computing. Wiley-IEEE Press.

8.3 Seminar Content	Teaching methods	Observations
1. Aristotelian Logic 2. Notions and concepts of fuzzy sets 3. Fuzzy numbers 4. Linguistic variables 5. Triangular norms 6. Fuzzy relations 7. Generalizations and extensions of fuzzy sets 8. Lattice theory; Boolean algebras; orthomodular lattices 9. Fuzzy logic 10. From quantum mechanics to quantum logic 11. Connections between fuzzy logic and quantum logic	Lecture Dialogue Exposure Problematization	

8.4 Seminar Bibliography

1. S. Nădăban, From Classical Logic to Fuzzy Logic and Quantum Logic: A General View, International Journal of Computers Communications & Control, 16(1), 2021.
2. S. Nădăban, Some fundamental properties of fuzzy linear relations between vector spaces, Filomat, 30(1) (2016).
3. S. Nădăban, D. Deac (2023). Nonstandard Fuzzy Sets: A General View. In: Dzitac, S., Dzitac, D., Filip, F.G., Kacprzyk, J., Manolescu, MJ., Oros, H. (eds) Intelligent Methods Systems and Applications in Computing, Communications and Control. ICCCC 2022. Advances in Intelligent Systems and Computing, vol 1435. 208-218, Springer, Cham.
4. S. Nădăban, S. Dzitac, I. Dzitac, Fuzzy TOPSIS: A general view, Promoting Business Analytics ond Quantitative Management of Technology: 4th International Conference on Information Technology and Quantitative Management (ITQM 2014), Procedia Computer Science, 91 (2016), 823-831.
5. S. Nădăban, I. Dzitac, Special Types of Fuzzy Relations, Information Technology and Quantitative Management (ITQM 2014), Procedia Computer Science, 31C (2014), 552-557.
6. Zadeh, L.A. (1965). Fuzzy Sets. Information and Control, 8(3), 338–353.
7. Zadeh, L.A. (1975). The Concept of a Linguistic Variable and Its Application to Approximate Reasoning. Information Sciences, 8(3), 199–249.
8. Klir, G.J., & Yuan, B. (1995). Fuzzy Sets and Fuzzy Logic: Theory and Applications. Prentice Hall.
9. Pedrycz, W., & Gomide, F. (2007). Fuzzy Systems Engineering: Toward Human-Centric Computing. Wiley-IEEE

8.5 Laboratory Content	Teaching methods	Observations

8.6 Laboratory Bibliography

8.7 Project Content	Teaching methods	Observations

8.8 Project Bibliography

9. Corroboration/validation of the content of the discipline (where applicable)

The content of the discipline is consistent with the content of similar disciplines from other university centers in the country and abroad. For a better adaptation of the content of the discipline to the requirements of the labor market, meetings were held with both employers - representatives of the business environment and with mathematics and computer science teachers from the pre-university education in Arad.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade
10.1. Course	**Preparing and presenting a report**	Oral evaluation (final in the exam session): Presentation of a final project Student's free presentation Evaluation conversation Oral questionnaire.	80%
10.2. Seminar	**The ability to operate with the acquired knowledge; - the ability to apply it in practice - conscientiousness, interest in study.**	Oral evaluation (final in the exam session): Completion and presentation of the final project. Homework, projects completed along the way. Active participation in the seminar.	20%
10.3. Laboratory			
10.4. Design			

10.5 Minimum performance standard

Mastering fundamental concepts, using specialized language, creating an application.

11. Learning outcomes

Knowledge: The graduate: a) documents himself/herself in relation to a given topic b) knows how to collect, classify and evaluate information from various sources c) critically summarizes new and complex information in relation to a given topic Skills: The graduate: a) correctly interprets the information collected on a given topic b) classifies the information available according to the context c) selects the information necessary to solve a specific problem d) uses digital tools to support information synthesis. Responsibility and autonomy: The graduate: a) uses the information at his disposal coherently b) demonstrates professionalism in managing the information at his disposal c) can work autonomously or in multidisciplinary teams

Knowledge: The graduate: a) defines concepts Understands the fundamental concepts underlying abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types b) Knows the principles of mathematical and formal logic, as well as demonstration methods c) formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples Skills: The graduate: a) provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the disciplines in the curriculum. b) represents and formulates concepts and problems in abstract, symbolic or formal terms c) creates abstract representations for computer structures: trees, graphs, recursive functions, object classes Responsibility and autonomy: The graduate: a) Demonstrates intellectual autonomy in exploring and manipulating abstract concepts b) finds solutions to practical, operational or conceptual problems, in a wide

range of contexts c) generates argumentative procedures in support of solutions Knowledge: The graduate: a) Knows advanced mathematical terminology, in Romanian and English b) Knows the conventions of notation, symbolization and formal presentation of mathematical content c) Transposes various practical problems into mathematical language d) Is able Skills: The graduate: a) Writes rigorous demonstrations, logical arguments and detailed explanations, using specific language b) Develops the solution to a problem in the field using appropriate symbols, language and mathematical tools c) Interprets and explains graphs, tables, mathematical models, numerical or symbolic results Responsibility and autonomy: The graduate: a) Communicates and interprets the solution to a problem b) Compares using specific mathematical language, alternative solutions c) Presents ideas and processes using appropriate symbols, language and mathematical tools d) Demonstrates rigor and intellectual discipline in writing and presenting one's own mathematical results

Knowledge: The graduate a) Has the ability to analyze and interpret complex relationships between quantities in interdisciplinary contexts b) Knows advanced methodologies for modeling and verifying relationships between quantities c) Can develop and evaluate hypotheses based on relationships between quantities in scientific research d) Has the ability to communicate and argue relationships between quantities in a clear and academic manner Skills: The graduate: a) Can examine and interpret relationships between variables in advanced mathematical, economic, scientific or social problems b) Can use statistical, mathematical or computational techniques to build and validate models involving relationships between variables. c) Can formulate and test hypotheses related to quantitative relationships within research projects. d) Can write reports, presentations or scientific publications that highlight and interpret relationships between variables. Responsibility and autonomy: The graduate a) Takes responsibility for the validity and accuracy of the interpretation of data and identified relationships. b) Takes the freedom to choose techniques and tools relevant to the specifics of the problem, assuming responsibility for the results obtained. c) Manages the research process autonomously, ensuring scientific rigor and academic integrity. d) Assumes responsibility for presenting and explaining conclusions clearly and with reason, assuming independence in writing and supporting scientific papers. Knowledge: The graduate: a) Constructively approaches scientific texts on a given topic b) Selects and organizes the information necessary to conduct research c) Compares and distinguishes related notions and their properties from advanced mathematical disciplines. d) Knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analyzing the results, validating or rejecting the hypothesis Skills: The graduate: a) Apply scientific methods and techniques to investigate current phenomena or practical problems b) Correct and integrate previous knowledge in current studies c) Use digital technology in the studies undertaken d) Recognize and analyze the necessary and/or sufficient conditions in the statement of mathematical assertions and specify their role in the demonstration Responsibility and autonomy: The graduate: a) Writes, edits and presents scientific texts b) Assumes responsibility for the correctness, coherence and clarity of the information presented c) Analyzes and interprets responsibly the results of the scientific research carried out d) Adapts the techniques and strategies for solving routine problems to solving synthesis problems and problems with a higher degree of complexity Knowledge: The graduate: a) Demonstrates advanced knowledge about the concepts and models of thinking analytical skills, including logical reasoning, causal analysis, critical evaluation of information and evidence-based decision-making. b) Understands methods for structuring complex problems, such as SWOT analysis, decision analysis, logical modeling and systemic approaches. c) Knows techniques for evaluating the validity and coherence of arguments, in academic and professional contexts. Skills: The graduate: a) Analyzes complex problems by breaking them down into essential components, identifying causal relationships and relevant factors. b) Critically evaluates information and arguments, identifying reasoning errors, cognitive biases and sources of uncertainty. c) Formulates rational and well-argued solutions, based on data, facts and logical principles. d) Apply analytical methods in decision-making, in interdisciplinary contexts and under conditions of uncertainty. Responsibility and autonomy: The graduate: a) Takes responsibility for the quality of the analysis process, demonstrating rigor, objectivity and coherence in reasoning. b) Makes autonomous decisions in complex situations, based on a critical assessment of alternatives and consequences. c) Promotes analytical thinking in teams and organizations, contributing to the development of a culture of reflection and informed decision-making. d) Demonstrates initiative in applyi Knowledge: The graduate: a) Knows the concepts and theories related to resilience, emotional intelligence and positive thinking, applicable in professional and personal contexts. b) Understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies. c) Knows models of positive leadership and manag

change, relevant for constructively addressing challenges in teams and organizations. Skills: The graduate: a) Identify and analyze challenges objectively, maintaining a balanced and solution-oriented attitude. b) Apply emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively.
c) Transforms obstacles into learning and development opportunities, demonstrating cognitive flexibility and openness to change.
d) Encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate. Responsibility and autonomy: The graduate: a) Takes responsibility for his/her own reactions to challenges, demonstrating emotional maturity and professionalism. b) Makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective. c) Acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture. d) Promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment.

Knowledge: The graduate: a) Knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research and decision-making. b) Understands the impact of minor errors on final results, in contexts such as data analysis, scientific writing, project management or professional communication.
c) Knows methods and techniques for verification and quality control, applicable in various fields of activity. Skills: The graduate: a) Identifies inconsistencies, errors or omissions in documents, data or processes, demonstrating a rigorous and systematic approach. b) Applies review and verification techniques to ensure the correctness and coherence of information. c) Respects formatting, structuring and presentation standards in writing texts, reports or scientific papers. d) Monitors details in complex activities, without losing sight of the overall objectives of the project.
Responsibility and autonomy: The graduate: a) Takes responsibility for the accuracy of their own work, demonstrating rigor and professionalism in delivering results. b) Works autonomously with a high level of attention to detail, even under pressure or deadlines. c) Contributes to maintaining quality standards in the team, providing constructive feedback and supporting quality control processes. d) Demonstrates consistency and discipline in verification and validation activities, contributing to reducing risks and increasing efficiency.

Knowledge: The graduate: a) Knows principles and methods of efficient organization of activity, including planning, prioritizing tasks and time management. b) Understands the concepts of personal productivity and professional performance, in individual and team contexts.
c) Knows digital tools and modern activity management techniques, useful for optimizing work processes. Skills: The graduate: a) Plans and structures activities effectively, setting clear objectives, realistic deadlines and adequate resources. b) Manages time and workload, adapting to priorities and deadlines without compromising quality. c) Uses agile or traditional working tools and methods to increase efficiency in individual or collaborative projects. d) Monitors progress and optimizes work processes, identifying and eliminating bottlenecks or resource losses. Responsibility and autonomy: The graduate: a) Takes responsibility for achieving the set objectives, demonstrating consistency and results orientation. b)Works autonomously and efficiently in complex contexts, maintaining a balance between quality, time and resources.
c)Contributes to making the team's work more efficient by proposing solutions and good organizational practices. d)Demonstrates initiative in continuously improving the way of working, adapting to changes and learning from experience

Course holder	Assistant	Director of the Department	Dean
Prof. Nădăban Sorin Florin	Prof. Nădăban Sorin Florin	Assoc. Prof. Popa Lorena Camelia	Prof. Nădăban Sorin Florin

MINISTERUL EDUCAŢIEI ŞI CERCETĂRII
UNIVERSITATEA „AUREL VLAICU“ DIN ARAD
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Tel : 0040-257- 283010; fax. 0040-257- 280070
http://www.uav.ro; e-mail: rectorat@uav.ro
Operator de date cu caracter personal nr.2929

SYLLABUS

1. Program Data

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Full-time education (FT)**

2. Data about Discipline

2.1. Name of the discipline	**GmET2O10 Research project in mathematical logic**
2.2. Education Plan Holder	**Prof. Dr. Nădăban Sorin Florin**
2.3. Assistant	**Prof. Dr. Nădăban Sorin Florin**
2.4. Year of study	**1**
2.5. Semester	**2**
2.6. Type of evaluation	**ES**
2.7. Discipline regime	**OB**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**2**
3.2. Class hours per week	**0**
3.3. Seminar/laboratory/project hours per week	**2**
3.4. Total hours in the curriculum	**28**
3.5. Course hours per semester	**0**
3.6. Seminar/laboratory/project hours per semester	**28**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**3**
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	**20**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**20**
3.4.4. Tutoring	**0**
3.4.5. Examinations	**4**
3.4.6. Other activities ...	**0**
3.7. Total hours of individual study	**47**

3.8. Total hours per semester	75
3.9. Number of credits	3

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	
4.2. Competence prerequisites	

5. Necessary conditions (where applicable)

5.1. Course conditions	
5.2. Conditions for holding the seminar	**That's not the case.**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C2. Synthesizes information** **C 4. Communicates mathematical information** **C11. Conducts scientific research** **C12. Applies the principles of ethics and scientific integrity in research activities**
6.2. Transversal skills	**CT1. Thinks analytically** **CT2. Approaches challenges positively** **CT3. Pays attention to details** **CT4. Works efficiently**

7. Discipline objectives (where applicable)

7.1. Objective general of the discipline	**Studying and deepening the fundamental concepts of mathematical logic, with an emphasis on formal structures, deductive systems and their applications in mathematics and theoretical computer science.**
7.2. Specific objectives	**Analyzing the main logical systems (classical, intuitionistic, modal, fuzzy) and comparing their fundamental principles.** **Applying logical methods in proof theory – identifying automatic proof algorithms and their role in artificial intelligence.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
8.2 Course Bibliography		
8.3 Seminar Content	Teaching methods	Observations
8.4 Seminar Bibliography		
8.5 Laboratory Content	Teaching methods	Observations
8.6 Laboratory Bibliography		
8.7 Project Content	Teaching methods	Observations
1. Analyzing the main logical systems (classical, intuitionistic, modal, fuzzy) and comparing their fundamental principles. 2. Applying logical methods in proof theory – identifying automatic proof algorithms and their role in artificial intelligence.	Participatory lecture, exposition, problematization, exemplification, demonstration, dialogue, exemplification	
8.8 Project Bibliography		

1. Mendelson, Elliott. – Introduction to Mathematical Logic. 6th Edition, Chapman and Hall/CRC, 2015.
2. van Dalen, Dirk. – Logic and Structure. 6th Edition, Springer, 2021.
3. Barwise, Jon & Etchemendy, John. – Language, Proof and Logic. University of Chicago Press, 2002.

9. Corroboration/validation of the content of the discipline (where applicable)

The content of the discipline is consistent with what is done in other university centers in the country and abroad. In order to adapt the content of the discipline to the requirements of the labor market, meetings were held with representatives of the business environment and with mathematics teachers from pre-university education.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight of the grade final
10.1. Course			
10.2. Seminar			
10.3. Laboratory			
10.4. Project	**Carrying out a project on a theme personalized for each student.**	Oral presentation of the project.	100%
10.5 Minimum performance standard **The project respects the received theme.**			

11. Learning outcomes

Knowledge: The graduate: a) documents himself/herself in relation to a given topic b) knows how to collect, classify and evaluate information from various sources c) critically summarizes new and complex information in relation to a given topic Skills: The graduate: a) correctly interprets the information collected on a given topic b) classifies the information available according to the context c) selects the information necessary to solve a specific problem d) uses digital tools to support information synthesis. Responsibility and autonomy: The graduate: a) coherently uses the information available b) demonstrates professionalism in managing the information available c) can work autonomously or in multidisciplinary teams Knowledge: The graduate: a) Knows advanced mathematical terminology, in Romanian and English b) Knows the conventions of notation, symbolization and formal presentation of mathematical content c) Transposes various practical problems into mathematical language d) Is able to express mathematical problems/theorems with practical implications in everyday language.

Skills: The graduate: a) Writes rigorous demonstrations, logical arguments and detailed explanations, using specific language b) Develops the solution to a problem in the field using appropriate symbols, language and mathematical tools c) Interprets and explains graphs, tables, mathematical models, numerical or symbolic results Responsibility and autonomy: The graduate: a) Communicates and interprets the solution to a problem b) Compares using specific mathematical language, alternative solutions c) Presents ideas and processes using appropriate symbols, language and mathematical tools
d) Demonstrates rigor and intellectual discipline in writing and presenting one's own mathematical results Knowledge: The graduate: a) Demonstrates advanced knowledge of scientific research methodology, including hypothesis formulation, experimental design, qualitative and quantitative methods. b) Understands the ethical and deontological principles of research, as well as applicable national and international regulations. c) Knows modern techniques for data collection and analysis, as well as methods for validating and interpreting results in interdisciplinary contexts Skills: The graduate: a) Formulates relevant research questions and testable hypotheses, in accordance with the specialized literature and the needs of the field. b) Designs and implements scientific studies, applying rigorous methods for collecting, analyzing and interpreting data. c) Writes scientific papers and research reports, using appropriate academic language and respecting citation and structuring rules. d) Uses digital and statistical tools to support the research process. Responsibility and autonomy: The graduate: a) Plans and carries out research activities autonomously, from defining objectives to disseminating results. b) Critically evaluates information sources, methods and research conclusions, assuming responsibility for the scientific rigor of the approach. c) Respects the principles of ethics and scientific integrity, avoiding plagiarism, data manipulation and other unethical practices. d) Actively contributes to the development of knowledge in the field of specialization, by participating in conferences, publishing articles and engaging in collaborative research projects.

Knowledge: The graduate: a) Demonstrates in-depth knowledge of the principles of research ethics, including informed consent, confidentiality, participant rights and responsible use of data. b) Knows the rules of scientific integrity, such as avoiding plagiarism, falsification and fabrication of data, as well as academic publishing standards. c) Understands the legal and institutional framework that regulates research activities, both at national and international levels. Skills: The graduate: a) Consistently applies ethical and integrity principles in all stages of research: design, data collection, analysis, interpretation and dissemination. b) Identify and manage ethical dilemmas that may arise in research activity, proposing solutions in accordance with professional norms. c) Drafts the necessary ethical documentation (e.g. requests for ethical approval, consent statements), respecting institutional requirements

and deontological. d) Uses sources and data responsibly, respecting copyright and academic citation rules. Responsibility and suonomy: The graduate: a) Assumes responsibility for respecting ethical and integrity norms, within individual or collaborative projects. b) Acts as a model of good ethical practices, contributing to the prevention and correction of unethical behavior in research. c) Makes autonomous decisions in complex ethical situations, demonstrating discernment and professional responsibility. d) Promotes a culture of ethics and scientific integrity in the academic and professional environment, through training, mentoring and institutional involvement.

Knowledge: The graduate: a) Demonstrates advanced knowledge of the concepts and models of analytical thinking, including logical reasoning, causal analysis, critical evaluation of information and evidence-based decision-making. b) Understands methods for structuring complex problems, such as SWOT analysis, decision analysis, logical modeling and systemic approaches. c) Knows techniques for evaluating the validity and coherence of arguments, in academic and professional contexts. Skills: The graduate: a) Analyzes complex problems by decomposing them into essential components, identifying causal relationships and relevant factors. b) Critically evaluates information and arguments, identifying reasoning errors, cognitive biases and sources of uncertainty. c) Formulates rational and well-argued solutions, based on data, facts and logical principles. d) Apply analytical methods in decision-making, in interdisciplinary contexts and under conditions of uncertainty. Responsibility and autonomy: The graduate: a) Takes responsibility for the quality of the analysis process, demonstrating rigor, objectivity and coherence in reasoning. b) Makes autonomous decisions in complex situations, based on a critical assessment of alternatives and consequences. c) Promotes analytical thinking in teams and organizations, contributing to the development of a culture of reflection and informed decision-making. d) Demonstrates initiative in applying analytical thinking to solve real problems, in academic, professional or social contexts.

Knowledge: The graduate: a) Knows the concepts and theories related to resilience, emotional intelligence and positive thinking, applicable in professional and personal contexts. b) Understands the psychological and social mechanisms of reaction to stress and uncertainty, as well as effective adaptation strategies. c) Knows models of positive leadership and change management, relevant for constructively addressing challenges in teams and organizations. Skills: The graduate: a)
Identify and analyze challenges objectively, maintaining a balanced and solution-oriented attitude. b) Apply emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively. c)
Transforms obstacles into learning and development opportunities, demonstrating cognitive flexibility and openness to change. d)
Encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate. Responsibility and autonomy: The graduate: a) Takes responsibility for his/her own reactions to challenges, demonstrating emotional maturity and professionalism. b) Makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective. c) Acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture. d) Promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment. Knowledge: The graduate: a) Knows the importance of accuracy and precision in academic and professional activities, especially in writing, analysis, research and decision-making. b) Understands the impact of minor errors on the final results, in contexts such as data analysis, scientific writing, project management or professional communication.c) Knows methods and techniques for verification and quality control, applicable in various fields of activity. Skills: The graduate: a) Identifies inconsistencies, errors or omissions in documents, data or processes, demonstrating a rigorous and systematic approach. b) Applies review and verification techniques to ensure the correctness and coherence of information. c) Respects formatting, structuring and presentation standards, in writing scientific texts, reports or papers. d) Monitors details in complex activities, without losing sight of the overall objectives of the project. Responsibility and autonomy: The graduate:
a) Takes responsibility for the accuracy of his/her own work, demonstrating rigor and professionalism in delivering results. b) Works autonomously with a high level of attention to detail, even under pressure or deadlines. c) Contributes to maintaining quality standards in the team, providing constructive feedback and supporting quality control processes. d) Demonstrates consistency and discipline in verification and validation activities, contributing to reducing risks and increasing efficiency. Knowledge: The graduate: a) Knows principles and methods of efficient organization of activity, including planning, prioritizing tasks and time management. b) Understands the concepts of personal productivity and professional performance, in individual and team contexts. c) Knows digital tools and modern activity management techniques, useful for optimizing work processes. Skills: The graduate: a) Plans and structures activities effectively, setting clear objectives, realistic deadlines and adequate resources. b) Manages time and workload, adapting to priorities and deadlines without compromising quality. c) Uses agile or traditional working tools and methods to increase efficiency in individual or collaborative projects.
d) Monitor progress and optimize work processes, identifying and eliminating bottlenecks or resource losses.

Responsibility and autonomy: The graduate: a) Takes responsibility for achieving the established objectives, demonstrating consistency and results orientation. b) Works autonomously and efficiently in complex contexts, maintaining a balance between quality, time and resources. c) Contributes to making the team's activity more efficient, by proposing solutions and good organizational practices.
d) Demonstrates initiative in continuously improving the way of working, adapting to changes and learning from experience

Course holder	Assistant	Director of the Department	Dean
Prof. Nădăban Sorin Florin	Prof. Nădăban Sorin Florin	Assoc. Prof. Popa Lorena Camelia	Prof. Nădăban Sorin Florin

SYLLABUS

1. Study Programme

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Program studied	**Mathematical modeling in science and technology**
1.8. Form of education	**Full – Time Study**

2. Course Details

2.1. Name of the discipline	**GmET1A11 Special chapters on stability**
2.2. Education Plan Holder	**Prof. Dr. Stoica Codruța Simona**
2.3. Assistant	**Prof. Dr. Stoica Codruța Simona**
2.4. Year of study	1
2.5. Semester	1
2.6. Type of evaluation	**Exam**
2.7. Discipline regime	**DA - Imposed compulsory discipline**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	3
3.2. Class hours per week	1
3.3. Seminar/laboratory/project hours per week	2
3.4. Total hours in the curriculum	**42**
3.5. Course hours per semester	**14**
3.6. Seminar/laboratory/project hours per semester	**28**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**22**
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	**30**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**30**
3.4.4. Tutoring	**22**
3.4.5. Examinations	4

3.4.6. Other activities ...	0
3.7. Total hours of individual study	**108**
3.8. Total hours per semester	**150**
3.9. Number of credits	6

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	**Differential equations and partial differential equations**
4.2. Competence prerequisites	**Working with advanced mathematical analysis concepts and methods**

5. Necessary conditions (where applicable)

5.1. Course conditions	**Classroom, equipped with a blackboard and video projector**
5.2. Conditions for holding the seminar	**Seminar room, properly equipped with a whiteboard and video projector**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C2. Synthesizes information** **C3. Thinks abstractly C4.** **Communicates mathematical information** **C6. Uses data processing techniques C10. Apply** **scientific methods**
6.2. Transversal skills	**CT1. Thinks analytically** **CT2. Approaches challenges positively CT3. Pays attention to details**

7. Discipline objectives (where applicable)

7.1. Objective general of the discipline	**- The student is able to apply elements of stability theory in the qualitative study of solutions to evolution equations** **- The student should be able to address the asymptotic behaviors of evolution cocycles, including stability and instability.** **- The student should be aware of the importance of studying the stability of solutions to evolution equations** **- The student should understand that in the study of phenomena that occur in the real world, often complex, it is necessary to create a schematization of them, called modeling.** **- The student should develop the ability to correctly apply the skills and knowledge acquired**
7.2. Specific objectives	**- The student demonstrates that he has mastered the notions of stability -** **- The student is able to demonstrate that he/she has understood the basic concepts in the study of stability: evolutionary cycles** **- The student is able to apply the acquired notions to the study of evolution equations that model phenomena in physics, engineering or economics.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. Stability theory. General issues	Participatory lecture, debate, exposure,	2 ore

	problematization, exemplification.	
2. Types of stability. Criteria of stability	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	2 ore
3. On families of operators in the study of differential and difference equations	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	3 ore
4. Asymptotic properties for skew-evolution semiflows: stability and instability	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	3 ore
5. On classes of dichotomy for skew-evolution semiflows	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	2 ore
6. On classes of trichotomy for skew-evolution semiflows	Participatory lecture, debate, exposure, problematization, exemplification, demonstration.	2 ore

8.2 Course Bibliography

1. J.T. Baldwin, Fundamentals of Stability Theory, Cambridge University Press, 2017 2. S. Buechler, Essential Stability Theory, Cambridge University Press, 2017 3. M. Megan, A.L. Sasu, B. Sasu, Asymptotic Behaviours of Evolution Families, Ed. Mirton, 2003 4. D.A. Sanchez, Ordinary Differential Equations and Stability Theory, Courier Dover Publications, 2019 5. C. Stoica, Uniform Asymptotic Behaviors for Skew-Evolution Semiflows on Banach Spaces, Ed. Mirton, 2010 6. L. Wen, Differentiable Dynamical Systems: An Introduction to Structural Stability and Hyperbolicity, American Mathematical Society, 2016 7. C.
8. C. Stoica, Course and seminar support, SUMS, 2025

8.3 Seminar Content	Teaching methods	Observations
1. Stability theory. General issues	Exercise, discussions and debate, modeling, project	4 ore
2. Types of stability. Criteria of stability	Exercise, discussions and debate, modeling, project	4 ore
3. On families of operators in the study of differential and difference equations	Exercise, discussions and debate, modeling, project	4 ore

4. Asymptotic properties for skew-evolution semiflows: stability and instability	Exercise, discussions and debate, modeling, project	8 ore
5. On classes of dichotomy for skew-evolution semiflows	Exercise, discussions and debate, modeling, project	4 ore
6. On classes of trichotomy for skew-evolution semiflows	Exercise, discussions and debate, modeling, project	4 ore

8.4 Seminar Bibliography

1. J.T. Baldwin, Fundamentals of Stability Theory, Cambridge University Press, 2017 2. S. Buechler, Essential Stability Theory, Cambridge University Press, 2017 3. M. Megan, A.L. Sasu, B. Sasu, Asymptotic Behaviours of Evolution Families, Ed. Mirton, 2003 4. D.A. Sanchez, Ordinary Differential Equations and Stability Theory, Courier Dover Publications, 2019 5. C. Stoica, Uniform Asymptotic Behaviors for Skew-Evolution Semiflows on Banach Spaces, Ed. Mirton, 2010 6. L. Wen, Differentiable Dynamical Systems: An Introduction to Structural Stability and Hyperbolicity, American Mathematical Society, 2016
7. C. Stoica, Course and seminar support, SUMS, 2025

8.5 Laboratory Content	Teaching methods	Observations

8.6 Laboratory Bibliography

8.7 Project Content	Teaching methods	Observations

8.8 Project Bibliography

9. Corroboration/validation of the course contents (where applicable)

The content of the course is in line with what is done in other university centers abroad. In order to adapt the content of the course to the requirements of the labor market, meetings were held with representatives of the business environment.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight from the note final
10.1. Course	**- correctness and completeness of knowledge; - logical coherence; - degree of assimilation of specialized language; -** **conscientiousness, interest in individual study.**	Oral evaluation (final in the exam session): - Student's free presentation; - Evaluation conversation; Oral questionnaire. Active participation in courses.	30% 10%
10.2. Seminar	**- the ability to operate with the acquired knowledge; - the ability to apply it in practice; -** **conscientiousness, interest in individual study.**	Oral assessment (final exam period): - completion of the required project - homework Active participation in seminars.	30% 10% 20%
10.3. Laboratory			
10.4. Design			

10.5 Minimum performance standard

Correct acquisition of basic theoretical concepts and their application in the study of the stability of solutions to equations differentials.

11. Learning outcomes

The graduate: a) documents himself/herself in relation to a given topic b) knows how to collect, classify and evaluate information from various sources c) critically summarizes new and complex information in relation to a given topic The graduate: a) correctly interprets the information collected on a given topic b) classifies the information available according to the context c) selects the information necessary to solve a specific problem d) uses digital tools to support information synthesis. The graduate: a) uses the information at his disposal coherently b) demonstrates professionalism in managing the information at his disposal c) can work autonomously or in multidisciplinary teams The graduate: a) defines concepts Understands the fundamental concepts underlying abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types b) Knows the principles of mathematical and formal logic, as well as demonstration methods c) formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples The graduate: a) provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the disciplines in the curriculum. b) represents and formulates concepts and problems in abstract, symbolic or formal terms c) creates abstract representations for computer structures: trees, graphs, recursive functions, object classes The graduate: a) Demonstrates intellectual autonomy in exploring and manipulating abstract concepts b) finds solutions to practical, operational or conceptual problems, in a wide range of contexts c) generates argumentative procedures in support of solutions The graduate: a) Knows advanced mathematical terminology, in Romanian and English b) Knows the conventions of notation, symbolization and formal presentation of mathematical content c) Transposes various practical problems into mathematical language d) Is able to express mathematical problems/theorems with practical implications in everyday language. The graduate: a) Writes rigorous demonstrations, logical arguments and detailed explanations, using specific language b) Develops the solution to a problem in the field using appropriate mathematical symbols, language and tools c) Interprets and explains graphs, tables, mathematical models, numerical results The graduate: a) Communicates and interprets the solution to a problem b) Compares using specific mathematical language, alternative solutions c) Presents ideas and processes using appropriate mathematical symbols, language and tools d) Demonstrates r Interprets data collection, processing and analysis techniques b) Identifies basic concepts suitable for organizing data in databases c) Explains the choice of basic models for organizing and managing data in databases The graduate: a) processes and analyzes relevant data and information b) Stores and updates data appropriately c) Apply statistical methods for description, estimation and hypothesis testing d) Creates relevant graphic visualizations to support data interpretation and responsibly communicates the results of data processing. The graduate: a) Constructively approaches scientific texts on a given topic b) Selects and organizes the information necessary to carry out research b) Compares and distinguishes related notions and their properties from advanced mathematical disciplines. c) Knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analyzing The graduate: a) Apply scientific methods and techniques to investigate current phenomena or practical problems b) Correct and integrate previous knowledge in current studies c) Use digital technology in the studies undertaken d) Recognize and analyze the necessary and/or sufficient conditions in the statement of mathematical assertions and specify their role in the Graduate: a) Write, edit and present scientific texts b) Assume responsibility for the correctness, coherence and clarity of the information presented c) Analyze and interpret responsibly the results of the scientific research carried out d)
Adapts routine problem-solving techniques and strategies to solve synthesis problems The graduate: a) Identifies and analyzes challenges objectively, maintaining a balanced and solution-oriented attitude. b) Applies emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively. c) Transforms obstacles into learning and development opportunities, demonstrating cognitive flexibility and openness to change. d) Encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate. The graduate: a) Takes responsibility for their own reactions to challenges, demonstrating emotional maturity and professionalism. b) Makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective. c) Acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture. d) Promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment.

Course Coordinator	Seminar Coordinator	Head of the Department	DEAN
Prof. Stoica Codruța Simona, PhD	Prof. Stoica Codruța Simona, PhD	Assoc. Prof. Lorena Camelia Popa, PhD	Prof. Sorin-Florin NĂDĂBAN, PhD

MINISTERUL EDUCAŢIEI ȘI CERCETĂRII
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http://www.uav.ro; e-mail: rectorat@uav.ro
Operator de date cu caracter personal nr.2929

SYLLABUS

1. Study Programme

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Program studied	**Mathematical modeling in science and technology**
1.8. Form of education	**Full – Time Study**

2. Course Details

2.1. Name of the discipline	**GmET1A12 Mathematical models in economics**
2.2. Education Plan Holder	**Prof. Dr. Stoica Codruța Simona**
2.3. Assistant	**Prof. Dr. Stoica Codruța Simona**
2.4. Year of study	1
2.5. Semester	1
2.6. Type of evaluation	**Exam**
2.7. Discipline regime	**DA - Imposed compulsory discipline**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	3
3.2. Class hours per week	1
3.3. Seminar/laboratory/project hours per week	2
3.4. Total hours in the curriculum	42
3.5. Course hours per semester	14
3.6. Seminar/laboratory/project hours per semester	28
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	30
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	35
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	35
3.4.4. Tutoring	0
3.4.5. Examinations	8

3.4.6. Other activities ...	0
3.7. Total hours of individual study	108
3.8. Total hours per semester	150
3.9. Number of credits	6

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	
4.2. Competence prerequisites	

5. Necessary conditions (where applicable)

5.1. Course conditions	**Classroom, equipped with a blackboard, laptop and video projector**
5.2. Conditions for holding the seminar	**Laboratory room, properly equipped with blackboard, computers, network, Internet connection.**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C2. Synthesizes information C3. Thinks abstractly C4. Communicates mathematical information C5. Studies relationships between quantities C6. Uses data processing techniques C7. Apply statistical analysis techniques C8. Performs data analysis C9. Identify statistical patterns** **C10. Apply scientific methods**
6.2. Transversal skills	**CT1. Thinks analytically** **CT2. Approaches challenges positively CT3. Pays attention to details CT4. Works efficiently CT5.** **Works in teams**

7. Discipline objectives (where applicable)

7.1. General objective of the discipline	**- The student is able to apply elements of mathematical modeling in the study of** **FINANCES** **- The student can use mathematical models to solve a concrete problem** **- The student should be aware of the importance of studying dynamic systems due to** **applications in computer science, mechanics, biology and economics** **- The student should understand that in the study of phenomena that occur in the world** **real, often complex, it is necessary to create a schematization of them, called modeling, which involves mathematical methods** **- The student should develop the ability to correctly apply skills and knowledge** **LEARNED**
7.2. Specific objectives	**- The student is able to demonstrate that he/she has understood the basic concepts of finance** **- The student can apply the acquired notions in modeling financial phenomena** **- The student is able to apply the acquired concepts to the study of other Sistema**

	dynamics that model phenomena in economics or engineering

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. Introduction to financial mathematics	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	4 ore
2. Financial securities and financial market: derivatives, interest rate, options, bonds	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	4 ore
3. Interest rate and annuities	Participatory lecture, debate, exposure, problematization, exemplification, demonstration.	4 ore
4. Financial asset portfolios	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	4 ore
5. The binomial model for estimating financial assets. European options	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	4 ore
6. The binomial model for estimating financial assets. American options	Participatory lecture, debate, exposure, problematization, exemplification, demonstration.	4 ore
7. Black & Scholes evaluation model	Participatory lecture, debate, exposition, problematization, exemplification, demonstration.	4 ore

8.2 Course Bibliography

1. F. Black, M. Scholes, The pricing of options and corporate liabilities. Journal of Political Economics 81, 384-404, 1973 2. V. Capasso, D. Bakstein, An Introduction to Continuous – Time Stochastic Processes, Theory, Models and Applications to Finance, Biology and Medicine, Birkhauser Boston, 2005
3. M. Capiÿski, T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer, 2nd Edition, 2011
4. R. J. Williams, Introduction to the Mathematics of Finance, American Mathematical Society, 2006
5. P. Wilmott, Derivatives. Financial Engineering, Economic Publishing House, Bucharest, 2002
6. C. Stoica, Course and seminar support, SUMS, 2025

8.3 Seminar Content	Teaching methods	Observations
1. Introduction to financial mathematics	Participatory lecture, debate, exposition, problematization, exemplification.	2 ore
2. Financial securities and financial market: derivatives, interest rate, options, bonds	Participatory lecture, debate, exposition, problematization, exemplification.	2 ore
3. Interest rate and annuities	Participatory lecture, debate, exposition, problematization, exemplification.	2 ore
4. Financial asset portfolios	Participatory lecture, debate, exposition, problematization, exemplification.	2 ore
5. The binomial model for estimating financial assets. European options	Participatory lecture, debate, exposition, problematization, exemplification.	2 ore
6. The binomial model for estimating financial assets. American options	Participatory lecture, debate, exposition, problematization, exemplification.	2 ore
7. Black & Scholes evaluation model	Participatory lecture, debate, exposure, problematization, exemplification.	2 ore

8.4 Seminar Bibliography

1. F. Black, M. Scholes, The pricing of options and corporate liabilities. Journal of Political Economics 81, 384-404, 1973

2. V. Capasso, D. Bakstein, An Introduction to Continuous – Time Stochastic Processes, Theory, Models and Applications to Finance, Biology and Medicine, Birkhauser Boston, 2005

3. M. Capiÿski, T. Zastawniak, Mathematics for Finance: An Introduction to Financial Engineering, Springer, 2nd Edition, 2011 4. R. J. Williams, Introduction to the Mathematics of Finance, American Mathematical Society, 2006 5. P. Wilmott, Derivative. Inginerie Financiară, Ed. Economicÿ , București, 2002

6. C. Stoica, Course and seminar support, SUMS, 2025

8.5 Laboratory Content	Teaching methods	Observations

8.6 Laboratory Bibliography

8.7 Project Content	Teaching methods	Observations

8.8 Project Bibliography

9. Corroboration/validation of the course contents (where applicable)

The content of the discipline is consistent with what is done in other university centers abroad.
To adapt the content of the discipline to the requirements of the labor market, meetings were held with representatives of the business environment.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight of final grade
10.1. Course	**- correctness and completeness of knowledge; - logical coherence; - degree of assimilation of specialized language; - conscientiousness, interest in individual study.**	Oral evaluation (final in the exam session): - Student's free presentation; - Evaluation conversation; Oral questionnaire. Active participation in courses.	30% 10%
10.2. Seminar	**- the ability to operate with the acquired knowledge; - the ability to apply it in practice; - conscientiousness, interest in individual study.**	Oral assessment (final exam period): -homework - project completion necessary Active participation in courses.	30% 10% 20%
10.3. Laboratory			
10.4. Design			

10.5 Minimum performance standard

Adequate acquisition of basic theoretical concepts and the ability to apply them in the study financial mathematical models.

11. Learning outcomes

The graduate: a) documents himself/herself in relation to a given topic b) knows how to collect, classify and evaluate information from various sources c) critically summarizes new and complex information in relation to a given topic The graduate: a) correctly interprets the information collected on a given topic b) classifies the information available according to the context c) selects the information necessary to solve a specific problem d) uses digital tools to support information synthesis. The graduate: a) uses the information at his disposal coherently b) demonstrates professionalism in managing the information at his disposal c) can work autonomously or in multidisciplinary teams The graduate: a) defines concepts Understands the fundamental concepts underlying abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types b) Knows the principles of mathematical and formal logic, as well as demonstration methods c) formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples The graduate: a) provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the disciplines in the curriculum. b) represents and formulates concepts and problems in abstract, symbolic or formal terms c) creates abstract representations for computer structures: trees, graphs, recursive functions, object classes The graduate: a) Demonstrates intellectual autonomy in exploring and manipulating abstract concepts b) finds solutions to practical, operational or conceptual problems, in a wide range of contexts c) generates argumentative procedures in support of solutions The graduate: a) Knows advanced mathematical terminology, in Romanian and English b) Knows the conventions of notation, symbolization and formal presentation of mathematical content c) Transposes various practical problems into mathematical language d) Is able to express mathematical problems/theorems with practical implications in everyday language. The graduate: a) Writes rigorous demonstrations, logical arguments and detailed explanations, using specific language b) Develops the solution to a problem in the field using appropriate mathematical symbols, language and tools c) Interprets and explains graphs, tables, mathematical models, numerical results The graduate: a) Communicates and interprets the solution to a problem b) Compares using specific mathematical language, alternative solutions c) Presents ideas and processes using appropriate mathematical symbols, language and tools d) Demonstrates rigor and intellectual discipline The graduate: a) interprets data collection, processing and analysis techniques b) Identifies basic concepts suitable for organizing data in databases c) Explains the choice of basic models for organizing and managing data in databases The graduate: a) processes and analyzes relevant data and information b) Stores and updates data appropriately c) Apply statistical methods for description, estimation and hypothesis testing d) Creates relevant graphic visualizations to support data interpretation and responsibly communicates the results of data processing. The graduate: a) Constructively approaches scientific texts on

a given topic b) Selects and organizes the information necessary to carry out a research b) Compares and distinguishes related notions and their properties from advanced mathematical disciplines. c) Knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analysis The graduate: a) Apply scientific methods and techniques to investigate current phenomena or practical problems b) Corrects and integrates previous knowledge in current studies c) Uses digital technology in the studies undertaken d) Recognizes and analyzes the necessary and/or sufficient conditions from the statement of mathematical assertions and specifies their role in the Graduate: a) Writes, edits and presents scientific texts b) Assumes responsibility for the correctness, coherence and clarity of the information presented c) Analyzes and interprets responsibly the results of the scie
Adapts routine problem-solving techniques and strategies to solve synthesis problems The graduate: a) Identifies and analyzes challenges objectively, maintaining a balanced and solution-oriented attitude. b) Applies emotional self-regulation and effective communication strategies to manage conflicts and pressures constructively. c) Transforms obstacles into learning and development opportunities, demonstrating cognitive flexibility and openness to change. d) Encourages a positive attitude in the team, contributing to maintaining a collaborative and motivating work climate. The graduate: a) Takes responsibility for their own reactions to challenges, demonstrating emotional maturity and professionalism. b) Makes autonomous decisions in difficult situations, maintaining a constructive and progress-oriented perspective. c) Acts as a model of positive behavior, beneficially influencing team dynamics and organizational culture. d) Promotes resilience and positive thinking in complex contexts, contributing to the sustainable development of the professional and academic environment. The graduate: a) Demonstrates advanced knowledge of the fundamental concepts and modern methods of statistical analysis, including descriptive, inferential statistics, regression, analysis of variance and multivariate models. b) Understands the theoretical principles underlying statistical methods, including their assumptions, limitations and conditions of applicability. c) Integrates statistical knowledge with the foundatio
The graduate: a) Selects and applies appropriate statistical methods depending on the nature of the data and the objectives of the research. b) Uses specialized computer tools to perform complex statistical analyses. c) Critically interprets statistical results, formulating relevant and data-supported conclusions. d) Visualizes and communicates results effectively, adapting their presentation to the target audience. The graduate: a) Plans and autonomously conducts statistical analysis processes, assuming responsibility for the correctness and relevance of the results. b) Critically evaluates the quality of data and the validity of the methods used, respecting scientific and ethical standards. c) Makes independent decisions regarding the selection of statistical techniques and the interpretation of results in complex contexts. The graduate: a) Demonstrates advanced knowledge of the data life cycle, from collection and cleaning to interpretation and reporting. b) Understands quantitative and qualitative data analysis methods, including explora
The graduate: a) Apply appropriate data analysis methods according to the objectives of the research or project. b) Use digital tools and programming languages to process, analyze and visualize data. The graduate: a) Plan and manage data analysis processes autonomously, from defining analytical questions to communicating results. b) Critically evaluate the quality of data and the validity of the methods used, assuming responsibility for the rigor and ethics of the analytical process. The graduate: a) Knows the principles of effective collaboration, including group dynamics, team roles, interpersonal communication, and conflict resolution. b) Understands collaborative work models, such as multidisciplinary, self-organized, or virtual teams. c) Knows techniques for facilitating and coordinating teams, applicable in academic and professional contexts.

Course Coordinator	Seminar Coordinator	Head of the Department	DEAN
Prof. Stoica Codruța Simona, PhD	Prof. Stoica Codruța Simona, PhD	Assoc. Prof. Lorena Camelia Popa, PhD	Prof. Sorin-Florin NĂDĂBAN, PhD

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Operator de date cu caracter personal nr.2929

SYLLABUS

Academic year 2025-2026

Study Year 1 / Semester 2

1. Program data

1.1 Higher education institution	**AUREL VLAICU UNIVERSITY OF ARAD**
1.2 Faculty	**of Exact Sciences**
1.3 Department	**Department of Mathematics and Computer Science**
1.4 Field of study	**Mathematics**
1.5 Study cycle	**Master**
1.6 Study program/qualifications COR/basic group ESCO *	**Mathematical Modeling in Science and Technology**

** according to the Curriculum*

2. Data about the discipline

2.1. Name of the discipline 2.3.		**Neural Models for Artificial Intelligence**				2.2 Code discipline	**GmEU2A21**	
Course activity coordinator			**Prof. dr. Beiu Valeriu**					
2.4 Seminar/laboratory activity coordinator			**Prof. dr. Beiu Valeriu**					
2.5 Year of study	1	2.6 Semester	2	2.7 Type of evaluation (E/C/VP)	**ES**	2.8 Discipline regime (**O** - compulsory, **Op** - optional, **F** - facultative)	**Op**	

3. Total estimated time

3.1 Number of hours per week	**3**	of which: 3.2 course	**1**	3.3 seminar/laboratory	**2**
3.4 Total hours in the Curriculum	**42**	of which: 3.5 course	**14**	3.6 seminar/laboratory	**28**
Distribution of time					**hours**
a. Study according to the textbook, course material, bibliography and notes					**40**
b. Additional documentation in the library, on specialized electronic platforms and in the field					**30**

c. Preparing seminars/laboratories, assignments, papers, portfolios and essays	30
d. Tutoring	0
e. Exams	4
f. Other university activities (study visits, project consultations, etc.)	4

3.7 Total hours of individual study (a+b+c)	100
3.8 Total hours of university activities (d+e+f+3.4)	50
3.9 Total hours per semester (3.7+3.8)	150
3.10 Number of credits **	6

** 1 credit = 25 hours*

*** It is recommended that 3.7 be greater than or equal to 3.8*

4. Preconditions (where applicable)

4.1 of curriculum	Recommended but not required: Fundamentals of Biological Neural Networks
4.2 of competences	Basic knowledge of programming, MATLAB and mathematical modeling

5. Conditions (where applicable)

5.1 For course	Classroom with whiteboard/interactive, video projector, and internet connection
5.2 For seminar	Seminar room with whiteboard/interactive, video projector, internet connection, computers and software for demonstrations (Matlab with Deep Learning toolbox si Simulink)
5.3 For laboratory	
5.4 For project	

6. Specific skills acquired

6.1 Professional skills	C1. Performs analytical mathematical calculations C5. Studies relationships between quantities C6. Uses data processing techniques C9. Identifies statistical models C10. Applies scientific methods
6.2 Transversal skills	CT1. Analytical thinking CT2. Positive approach to challenges CT3. Pays attention to details

7. The objectives of the discipline (based on the list of specific skills acquired)

7.1 General objective of the discipline	Students will become familiar with new concepts of neural inspiration, in particular they will understand new mathematical models for representing artificial neurons and for modeling complex systems (artificial neural networks), including artificial learning processes. All of these will allow them to adjust to new technologies, increase their chances of integration into interdisciplinary teams, as well as their ability to provide consultancy in applied informatics.
7.2 Specific objectives	Students will be able to demonstrate that they have acquired knowledge regarding: Modeling an artificial neuron (perceptron, Hodgkin-Huxley, simplified models) Advantages and disadvantages Supervised learning (perceptron, backpropagation, deep learning) Complexity of logic circuits with threshold gates (perceptron networks) Dendritic computations (the perceptron as sub-neuronal logic) Unsupervised learning

8. Contents *

8.1 Course	**Teaching methods**	**Remarks**
1.- Introduction and general notions History of the evolution of neural computing models 2.- From cell theory to the McCulloch model Pitts (the perceptron) 3.- Development of perceptrons (Rosenblatt) Criticism of this model (Minsky & Papert) 4.- Supervised learning: The perceptron algorithm ADALINE and MADALINE (Bernard Widrow) 5.- Supervised learning: Backpropagation (Paul Werbos, Yan LeCun, etc.) 6.- Latest results: From Backpropagation to Deep learning (with Geoffrey Hinton, Demis Hassabis, etc.) Discuss: AlphaGo won; What does this mean for AI; But for neural models/networks? 7.- The Hodgkin-Huxley model (biologically inspired) 8.- Alternative (simplified) models of a neuron 9.- Transmission modeling (synapses, dendrites, axons) 10.- The perceptron as a threshold logic gate Boolean logic implemented with perceptrons 11.- The complexity of logic circuits with perceptrons 12.- Dendritic computations The perceptron as sub-neuronal logic 13.- From Shannon (1938) to Nicolau et al. (2016) 14.- Unsupervised learning: The Hierarchical Temporal Memory Model (with Jeff Hawkins from Numeta)	Free presentation Presentation using the overhead projector and the internet Debate (interactive) Modeling Comparative analysis Brainstorming Example	2 hours for each course

8.2 Bibliography

1. W.S. McCulloch, and W.H. Pitts, A logical calculus of the ideas immanent in nervous activity, Bulletin of Mathematical Biophysics, vol. 5, no. 4, pp. 115133, Dec. 1943.
2. A.L. Hodgkin, and A.F. Huxley, A quantitative description of membrane current and its application to conduction and excitation in nerve, The Journal of Physiology, vol. 117, no. 4, pp. 500544, Aug. 28, 1952. http://dx.doi.org/10.1113/jphysiol.1952.sp004764
3. W.A. Catterall, I.M. Raman, H.P.C. Robinson, T.J. Sejnowski, and O. Paulsen, The Hodgkin-Huxley heritage: From channels to circuits, The Journal of Neuroscience, vol. 32, no. 41, pp. 1406414073, Oct. 10, 2012. http://dx.doi.org/10.1523/ JNEUROSCI.3403-12.2012
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26. S.R. Cowell, V. Beiu, L. Daus, and P. Poulin, On hammock networks Sixty years after, IEEE International Conference on Design & Technology of Integrated Systems in Nanoscale Era (DTIS17), Palma de Mallorca, Spain, art. 7929871(16), Apr. 4-6, 2017

8.3 Seminar	Teaching methods	Remarks
1.- Matlab: Introduction (fundamental commands) 2.- Matlab: Using matrices 3.- Matlab: Graphic visualization 4.- Matlab: Simple examples 5.- Matlab: Complex examples 6.- Supervised learning: Perceptrons 7.- Supervised learning: Backprop(agation) and deep learning 8.- Discussing https://nanohub.org/courses/BIOELEC and the Hodgkin-Huxley model (in Matlab) 9.- The simulator http://www.cs.cmu.edu/~dst/HHsim/ (in Matlab) 10.- Simplified models (Morris-Lecar, FitzHugh-Nagumo) 11.- Complex models (including multiple ion channels, statistical ehavior, etc.) 12.- Leaky-integrate-and-fire (LIF) model Izhikevich model 13.- Modeling dendrites and axons 14.- Modeling synapses and their plasticity	Case studies Exemplification Study (individual) Documentation (on web) Analyses and comparisons	2 hours for each seminar.

8.4 Bibliography

1. Matlab 2021, https://www.mathworks.com/products/matlab.html
2. Simulink, https://www.mathworks.com/products/simulink.html
3. Deep Learning, https://www.mathworks.com/products/deep-learning.html
4. Reinforcement Learning, https://www.mathworks.com/products/reinforcement-learning.html
5. Statistics and Machine Learning, https://www.mathworks.com/products/statistics.html
6. V. Beiu, Seminar/laboratory support, SUMS platform 2025-2026

8.5 Laboratory	Teaching methods	Remarks
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8.6 Bibliography

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8.7 Project	Teaching methods	Remarks
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8.8 Bibliography

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** course and seminar/ laboratory assignments must fully cover the specific objectives formulated in section 7.2.*
** the topics addressed in the course and those in the seminar can be designed both in a complementary relationship and/ or for deepening the topic.*
** It is advisable that the development of the syllabus should be done as a team by the course and seminar/ laboratory coordinators, possibly by all the holders of the same subject, where several people teach the same subject.*

9. Corroborating the content of the discipline with the expectations of representatives of the epistemic community, professional associations and representative employers in the field related to the program

This course is taught in similar programs at many universities, both in Romania and abroad. For a better matching with the demands of the labor market, meetings with employers' representatives, business representatives, and mathematics and computer science teachers from the Arad pre-university education system have been organized.

10. Evaluation

Activity type	Evaluation criteria	Evaluation methods	Weight on final grade
10.1 Course	Degree of assimilation of specialized language Logical coherence Correctness and completeness of knowledge Conscientiousness Interest Tenacity	Contributions/questions in course time Conversation (of evaluation) Evaluation final (in exams)	50% -- Final evaluation 10% -- Participation active
10.2 Seminar	The ability to use acquired knowledge The ability to apply knowledge in practice theoretical Conscientiousness Interest Tenacity	Paper / presentation Homework/work	25% -- Report / presentation 10% -- Homework/work 5% -- Active participation
10.3 Laboratory			
10.4 Project			
10.5 Minimum performance standard Correct mastery of the basic notions, understanding of fundamental concepts, mastery of specialized language, the ability to analyze and explain simple cases.			

11. Results of learning

a) knows how to collect, classify and evaluate information from various sources b) critically summarizes new information and complex questions related to a given topic c) understands the fundamental concepts that underlie abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types d) translates various practical problems into mathematical language e) has the ability to analyze and interpret complex relationships between quantities in interdisciplinary contexts f) knows advanced methodologies for modeling and verifying relationships between quantities g) constructively approaches scientific texts on a given topic h) knows The stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analyzing results, validation or rejection of the hypothesis

Course coordinator	Seminar/laboratory/project coordinator	Head of the Department	Dean
Prof. Beiu Valeriu	**Prof. Beiu Valeriu**	**Assoc. Prof. Lorena Camelia POPA**	**Prof.Sorin-Florin NĂDĂBAN**

MINISTERUL EDUCAŢIEI ȘI CERCETĂRII
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Operator de date cu caracter personal nr.2929

DISCIPLINE SHEET

1. Program Data

1.1. Higher education institution	**"AUREL VLAICU" UNIVERSITY OF ARAD**
1.2. Faculty	**of Exact Sciences**
1.3. Department	**Department of Mathematics-Informatics**
1.4. Field of study	**Mathematics**
1.5. Academic year	**2025-2026**
1.6. Study cycle	**Master**
1.7. Specialization / Study program	**Mathematical modeling in science and technology**
1.8. Form of education	**Part-time education (FI)**

2. Data about Discipline

2.1. Name of the discipline	**GmEU2A22 Dilation theory and operational models**
2.2. Education Plan Holder	**Associate Professor Dr. Gaspar Octavian Pastorel**
2.3. Assistant	**Associate Professor Dr. Gaspar Octavian Pastorel**
2.4. Year of study	**1**
2.5. Semester	**2**
2.6. Type of evaluation	**IS**
2.7. Discipline regime	**On**

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	**3**
3.2. Class hours per week	**1**
3.3. Seminar/laboratory/project hours per week	**2**
3.4. Total hours in the curriculum	**42**
3.5. Course hours per semester	**14**
3.6. Seminar/laboratory/project hours per semester	**28**
	Time distribution [Hours]
3.4.1. Studying according to the textbook, course material, bibliography and notes	**50**
3.4.2. Additional documentation in the library, on electronic platforms specialty and on the ground	**25**
3.4.3. Preparation of seminars/laboratories, assignments, papers, portfolios and essays	**30**
3.4.4. Tutoring	**0**
3.4.5. Examinations	**3**

3.4.6. Other activities ...	0
3.7. Total hours of individual study	108
3.8. Total hours per semester	150
3.9. Number of credits	6

4. Preconditions (where applicable)

4.1. Curriculum prerequisites	**Real and complex analysis** **Functional analysis**
4.2. Competence prerequisites	**the ability to extract essential information from international specialized literature**

5. Necessary conditions (where applicable)

5.1. Course conditions	**classroom equipped with a blackboard and video projector or with a smart board**
5.2. Conditions for holding the seminar	**seminar room equipped with a whiteboard and video projector or with a smart board**
5.3. Laboratory conditions	
5.4. Project implementation conditions	

6. Specific skills acquired (where applicable)

6.1. Professional skills	**C2. Synthesizes information** **C3. Thinks abstractly C4.** **Communicates mathematical information** **C5. Studies relationships between** **quantities C10. Apply scientific methods**
6.2. Transversal skills	**CT1. Thinks analytically** **CT2. Approaches challenges positively CT3. Pays attention to details** **CT4. Works efficiently**

7. Discipline objectives (where applicable)

7.1. Objective general of the discipline	**Accumulation of knowledge regarding dilation contractions and functional models for operators.** **The student should develop the skills to correctly apply the acquired knowledge to solve different classes of problems.** **The student must train and develop his analytical ability.**
7.2. Specific objectives	**The student is able to demonstrate that he/she has acquired sufficient knowledge to understand concepts such as: Hilbert contraction, unitary dilation of a Hilbert contraction, characteristic function of a Hilbert contraction.** **The student is able to correctly apply basic methods and principles in solving complex problems.** **The student can carry out projects for the mathematical modeling of a concrete problem.**

8. Contents (where applicable)

8.1 Course Content	Teaching methods	Observations
1. Unitary extensions of isometric operators. Subnormal operators. 2. Hilbert contractions and their canonical decomposition. 3. Unilateral translations and their functional model 4. Functional calculus for Hilbert contractions. 5. Unitary dilation of Hilbert contractions. Geometric structure of the dilation space. 6. The characteristic function of a Hilbert contraction and its functional-operator model	Interactive exhibition	
8.2 Course Bibliography		

1. A. Gheondea, Operator models for Hilbert locally Cÿ-modules, Operators and matrices 11 (3), 2017, pp. 639 –667.
2. D. Han, D. R. Larson, B. Liu, R. Liu, Operator-valued measures, dilations, and the theory of frames, AmerMathematical Society, Memoirs of the American Mathematical Society 1075, 2014.
3. B. Sz.-Nagy, C. Foias, H. Bercovici, L. Kérchy, Harmonic analysis of operators on Hilbert space, Springer-Verlag NewYork, 2010.

8.3 Seminar Content	Teaching methods	Observations
1. Unitary extensions of isometric operators. Subnormal operators. 2. Hilbert contractions and their canonical decomposition. 3. Unilateral translations and their functional model 4. Functional calculus for Hilbert contractions. 5. Unitary dilation of Hilbert contractions. Geometric structure of the dilation space. 6. The characteristic function of a Hilbert contraction and its functional-operator model	Exercise, discussions and debate, modeling, project	

8.4 Seminar Bibliography

1. A. Gheondea, Operator models for Hilbert locally Cÿ-modules, Operators and matrices 11 (3), 2017, pp. 639 –667.
2. D. Han, D. R. Larson, B. Liu, R. Liu, Operator-valued measures, dilations, and the theory of frames, AmerMathematical Society, Memoirs of the American Mathematical Society 1075, 2014.
3. B. Sz.-Nagy, C. Foias, H. Bercovici, L. Kérchy, Harmonic analysis of operators on Hilbert space, Springer-Verlag NewYork, 2010.

8.5 Laboratory Content	Teaching methods	Observations

8.6 Laboratory Bibliography

8.7 Project Content	Teaching methods	Observations

8.8 Project Bibliography

9. Corroboration/validation of the content of the discipline (where applicable)

The content of the discipline is consistent with what is done in other university centers abroad.

10. Evaluation (where applicable)

Activity type	Evaluation criteria	Evaluation methods	Weight from the note final
10.1. Course	**- correctness and completeness of knowledge; - logical coherence; - degree of assimilation of specialized language;**	Oral assessment: free student presentation; oral questionnaire; evaluation conversation	60%
10.2. Seminar	**- the ability to operate with the acquired knowledge; - the ability to apply it in practice;**	individual project	40%
10.3. Laboratory			
10.4. Design			

10.5 Minimum performance standard

Knowledge of the fundamental elements of theory, logical coherence in exposition, solving a simple application.

11. Learning outcomes

Knowledge: C2: The graduate: a) documents himself/herself in relation to a given topic b) knows ways of collecting, classifying and evaluating information from various sources c) critically summarizes new and complex information in relation to a given topic C3: The graduate: a) defines concepts Understands the fundamental concepts underlying abstract thinking: axioms, theorems, demonstrations, structures, functions, relations, abstract data types b) Knows the principles of mathematical and formal logic, as well as demonstration methods c) formulates observations and differentiates notions, properties and assertions from the basic disciplines of mathematics through examples and counterexamples C4: The graduate: a) Knows advanced mathematical terminology, in Romanian and English b) Knows the conventions of notation, symbolization and formal presentation of mathematical content c) Transposes various practical problems into mathematical language d) Is able to express mathematical problems/theorems with practical implications in everyday language. C5: The graduate a) Has the ability to analyze and interpret relationships

complex relationships between quantities in interdisciplinary contexts b) Knows advanced methodologies for modeling and verifying relationships between quantities c) Can develop and evaluate hypotheses based on relationships between quantities in scientific research d) Has the ability to communicate and argue relationships between quantities in a clear and academic manner C10: The graduate: a) Constructively approaches scientific texts on a given topic b) Selects and organizes the information necessary to carry out research c) Compares and distinguishes related notions and their properties from advanced mathematical disciplines. d) Knows the stages of scientific methodology: formulating a hypothesis, modeling the problem, choosing the method, experimenting, analyzing the results, validating or rejecting the hypothesis Skills C2: The graduate: a) correctly interprets the information collected on a given topic b) classifies the information available according to the context c) selects the information necessary to solve a specific problem d) uses digital tools to support information synthesis. C3: The graduate: a) provides examples of the use of basic theoretical concepts and results when solving exercises and problems formulated in relation to the topics covered in the curriculum subjects. b) represents and formulates concepts and problems in abstract, symbolic or formal terms c) creates abstract representations for computer structures: trees, graphs, recursive functions, object classes C4: The graduate: a) Writes rigorous demonstrations, logical arguments and detailed explanations, using specific language b)

Develops a solution to a problem in the field using appropriate mathematical symbols, language and tools c) Interprets and explains graphs, tables, mathematical models, numerical or symbolic results C5: The graduate: a) Can examine and interpret relationships between variables in advanced mathematical, economic, scientific or social problems b) Can use statistical, mathematical or computational techniques to build and validate models involving relationships between variables. c) Can formulate and test hypotheses related to quantitative relationships within research projects. d) Can write reports, presentations or scientific publications that highlight and interpret relationships between variables. C10: The graduate: a) Apply scientific methods and techniques to investigate current phenomena or practical problems b) Corrects and integrates previous knowledge in current studies c) Uses digital technology in studies undertaken d) Recognizes and analyzes the necessary and/or sufficient conditions in the statement of mathematical assertions and specifies their role in the demonstration.

Responsibility and autonomy C2: The graduate: a) uses the information at his disposal coherently b) demonstrates professionalism in managing the information at his disposal c) can work autonomously or in multidisciplinary teams C3: The graduate: a) Demonstrates intellectual autonomy in exploring and manipulating abstract concepts b) finds solutions to practical, operational or conceptual problems, in a wide range of contexts c) generates argumentative procedures in support of solutions C4: The graduate: a) Communicates and interprets the solution to a problem b) Compares alternative solutions using specific mathematical language c) Presents ideas and processes using appropriate mathematical symbols, language and tools d) Demonstrates rigor and intellectual discipline in writing and presenting his own mathematical results C5: The graduate a) Assumes responsibility for the validity and accuracy of the interpretation of the data and relationships identified. b) Takes the freedom to choose techniques and tools relevant to the specifics of the problem, assuming responsibility for the results obtained. c) Autonomously manages the research process, ensuring scientific rigor and academic integrity. d) Assumes responsibility for presenting and explaining conclusions clearly and with justification, assuming independence in writing and supporting scientific papers. C10: The graduate: a) Writes, edits and presents scientific texts b) Assumes responsibility for the correctness, coherence and clarity of the information presented c) Analyzes and interprets the results of scientific research carried out responsibly d) Adapts techniques and strategies for solving routine problems to solving synthesis problems and problems with a higher degree of complexity

Titular	Assistant	Director Department	DEAN
Associate Professor Dr. Gaspar Octavian Pastorel	Associate Professor Dr. Gaspar Octavian Pastorel	Conf.univ.dr. Lorena Camelia Popa	Prof. Sorin-Florin NADABAN, PhD