MD-2045, CHISINAU, 7/9 STUDENTILOR STR, , PHONE: 022 50-99-01 | FAX: 022 50-99-05, www.utm.md

MATHEMATICAL MODELS AND OPTIMIZATIONS

1. Course/Module information

Faculty	Computers, Informatics, and Microelectronics				
Department	Informatics and Systems Engineering				
Study cycle	Master's Studies, Cycle II				
Study program	**Data Science**				
Year of study	**Semester**	**Type of evaluation**	**Formative category**	**Optionality category**	**ECTS credits**
I (full-time education)	1	E	F – fundamental course unit	O - mandatory course unit	5

2. Estimated total time

Total hours in the curriculum	Including				
	Auditory hours		Individual work		
	lecture	Laboratory/seminar	Year project	Study of theoretical material	Application preparation
150	20	20/0	-	55	55

3. Prerequisites for access to the course/module

According to the curriculum plan	Special mathematics, Discrete mathematics, Computer programming, Data structures and algorithms, Models and computation methods, Numerical methods, Operations research, Databases, Web technologies, Systems theory.
According to competencies	Acquiring theoretical and practical knowledge of modeling through methods of information accumulation, processing, and transfer, and mastering modern optimization methods.

4. Conditions for conducting the educational process

Lecture	A projector and computer are required to present the theoretical material in the classroom. Student delays, as well as phone conversations during the course, will not be tolerated.
Laboratory/seminar	Students will complete reports according to the conditions set by the methodological guidelines. The deadline for submitting the laboratory work is one week after its completion. Late submission of the work will result in a penalty of 1 point per week of delay.

5. Specific competencies acquired

Professional competencies	**CPM1** System architecture development and design **CPM2** Monitoring technological trends. Innovation. Sustainable development. **CPM3** Application development. Component integration. Systems engineering. **CPM 5.** Process improvement.

Transversal competencies	**CTM1** Autonomy and responsibility **CTM2** Social interaction **CTM3** Personal and professional development

6. Course/Module objectives

General objectives	At the level of knowledge and understanding: ✓ Technical-engineering models and types of optimization problems; ✓ Most common methods for solving linear programming problems (simplex algorithm, dual simplex algorithm, interior point method, solution sensitivity); ✓ Methods for solving convex programming and semidefinite programming problems (gradient methods, conjugate direction methods, Lagrange multiplier method, interior point methods); ✓ Elements of game theory and queueing theory. Reduction to mathematical programming problems.
Specific objectives	At application and integration level, the master's student must be able to: ✓ use mathematical models and optimization methods to apply them in determining the optimal solutions for mathematical programming problems, semidefinite programming, combinatorial optimization, game theory problems, and queueing theory problems; ✓ develop the algorithm for solving the considered problem and write the program in a programming language according to the algorithm and be able to use software products such as QM, Excel, Matlab, Mathematica, Maple, etc., for solving practical problems on the electronic computer.

7. Course/Module content

Syllabus of teaching activities	Number of hours	
	Full-time education	Part-time education
Syllabus of lecture activities		
T1. Introduction. Modeling and optimization. The problem-solving process. High-performance computing. Complexity. Types of optimization problems. Considerations on modeling and optimization. Current state of optimization software.	2	-
T2. Technical-engineering and macroeconomic models. The link between modeling and optimization. Linear vs. nonlinear. Large-scale models. Model generation. Model preprocessing. Model postprocessing. Allocation models. Distribution models. Model development.	4	-
T3. Elements of convex analysis. Convex sets. Segments. Convex polyhedra. Extreme points. Separation theorems for convex sets. Convex functions. Strictly and strongly convex functions. Unconstrained optimization. Conditions for extrema in unconstrained optimization. Gradient and conjugate direction methods. Newton-Raphson method. Quasi-Newton methods.	2	-
T4. Linear optimization. General linear optimization problem. Practical examples of linear optimization problems. Duality in linear optimization. Dual theorems of linear programming. Reoptimization and parameterization in linear programming. Sensitivity analysis of optimal solutions.	2	-
T5. Integer linear optimization. The knapsack problem. Assignment problem. The traveling salesman problem. Cutting and branching methods.	2	-
T6. Elements of game theory. Matrix games. Solving games using linear programming. Reducing linear programming problems to a matrix game. Symmetric matrix games. Matrix solution for symmetric games. Applications.	4	-
T7. Nonlinear optimization problems. Nonlinear programming problems with equality constraints. Lagrange function. Necessary and sufficient conditions for extrema. Nonlinear programming problems with inequality constraints.	2	-

Quadratic programming. Kuhn-Tucker conditions. Newton-type methods. Applications.		
T8. Examples and applications of semidefinite programming. Non-convex combinatorial optimization. Structural optimization. Software packages for semidefinite programming.	2	-
Total lectures:	**20**	**-**

Syllabus of seminar/practical work activities	Number of hours	
	Full-time education	Part-time education
LL1. Technical-engineering models. Use of software products in the study of models associated with optimization problems.	4	-
LL2. Linear optimization models. Presentation and analysis of linear mathematical models associated with linear programming problems.	8	-
LL3. Solving matrix games. Exemplifying mathematical modeling techniques presented in the course.	4	-
LL4. Solving nonlinear optimization problems. Quadratic programming. QM software product.	4	-
Total laboratory works:	**20**	**-**

8. Using generative AI

Permission to use	The use of generative AI in assignments and projects is permitted, provided that students adhere to the following rules: • Generative AI may be used to generate ideas, text structures, or code, but all generated materials must be reviewed and adjusted by the student to ensure that they meet academic requirements. • Any use of generative AI must be declared in the appendix section of each paper, using the phrase: "During the preparation of this paper, the author used [NAME OF TOOL / SERVICE] for the purpose of [REASON]. After using this tool / service, the author reviewed and edited the content as necessary and assumes full responsibility for the content of the paper."
Restrictions to use	Students ***MUSTN'T consider generative AI as a reliable source of information***, as it does not provide clear references or documented sources. • ***Direct citation of AI-generated content*** in academic papers as if it were a primary source ***isn't permitted.*** • Activities in which the use of **generative AI is prohibited** are specified by the teacher and are usually ***intermediate and final assessments*** or that don't involve professional competence development activities.

9. Bibliographic references

Main	1. Moraru V. Metode de calcul numeric şi optimizări. Note de curs. Secţia Redactare şi Editare a U.T.M., 2009. -304 p. ISBN 978-9975-45-108-6. 2. Moraru V., Popescu A. Rezolvarea numerică a ecuaţiilor neliniare şi a problemelor de optimizare necondiţionată. Ciclu de prelegeri. Departamentul Editorial - Poligrafic al U.T.M., Chişinău, 1997.-88 p. 3. Moraru V., Pârţachi I., Berzan R. Introducere în optimizarea liniară. Chişinău, Editura A.S.E. 1997.

	4. Andrei N. Pachete de programe, modele şi probleme test pentru programarea matematică. MatrixRom, Bucureşti, 2001 5. Trandafir R. Modele și algoritmi de optimizare. Editura AGIR Bucureşti, 2004. 252 p. http://civile.utcb.ro/mao.pdf 6. Necoară I. Metode de optimizare numerică. Editura Universitatea Politehnica din Bucureşti. 2013. 278 p. http://141.85.225.150/courses/curs_to.pdf
Supplementary	1. Jeffrey Paul Wheeler. ***An Introduction to Optimization with Applications in Machine Learning and Data Analytics***. Publisher CRC Press, Chapman and Hall/CRC , 2023, 473 p. ISBN 0367425505, ISBN13: 978-0367425500. DOI https://doi.org/10.1201/9780367425517 2. Roberto Cominetti, Francisco Facchinei, Jean B. Lasserre ***Modern Optimization Modelling Techniques*.** 2012, 269 p. Publisher: Birkhauser Springer Basel ISBN: 978-3-0348-0290-1 . DOI 10.1007/ 978-3-0348-0291-8 3. Andrei N. Programarea matematică avansată: teorie, metode computaţionale, aplicaţii, Ed. Tehnică, Bucureşti (1999); 4. Andrei N. Programare semidefinită. MatrixRom, Bucureşti, 2001. • Blajină Ovidiu. – Cercetări operaţionale, Ed.Printech 2001 • Ciobanu Gh., Nica V., Mustaţă F., Mărăcine V., Mitruţ D. – Cercetări Operaţionale, Ed. MatrixRom, Bucureşti, 2002 • Dumitrescu M., Niculescu C. – Teoria deciziei şi Cercetare Operaţională, Ed. Niculescu, Bucureşti, 2001; • Hillier F., Limberman G., Introduction to operational research, McGraw-Hill Publishing Company, New-York, 1990 • Kaufmann A, Metode şi modele ale cercetării operaţionale, Ed,Ştiinţifică, Bucureşti, 1967 5. Гилл Ф., Мюррэй У., Райт У**.** Практическая оптимизация. М. : Мир, 1985.-509р. (traducere din limba engleză Gill Ph., Murraz M., Wright M. Practical optimization. Academic Press,1981). 6. Муртаф Б**.** Современное линейное програмирование. Теория и практика. М.: Мир, 1984.-224р. (traducere din limba engleză Murtagh B. Advanced linear programming: computation and practice, 1981). 7. Поляк Б.Т. Введение в оптимизацию. М.: Наука, 1983.-384р. 8. Схрейвер А. Теория линейного и целочисленного програмирования. М. :Мир, 1991.-360р. (traducere din limba engleză Schrijver A. Theory of linear and integer programming 1990) 9. Lucrări practice. Studiile de caz rezolvate cu produsul informatic QM. ASE Bucureşti, 1994.

10. Evaluation

Current		Term paper	Final exam
Mid-term 1	Mid-term 2		
30%	30%		40%
Minimum performance standard			
Attendance and participation in lectures and laboratory work; Achieving a minimum grade of "5" in each of the certifications and laboratory works; Achieving a minimum grade of "5" in the term project; Demonstrating knowledge of the conditions for applying constructive modeling methods in the final exam paper.			

11. Evaluation criteria

Activity	Evaluation components	Evaluation method, evaluation criteria	Weight in final grade for the Activity	Weight in course evaluation
Full-time education				
Mid term I	Theoretical content, topics 1-3	Test	100%	**15%**
Mid term II	Theoretical content, topics 4-5	Activities during practical work/seminar	100%	**15%**
Current evaluation	Practical activity	Attendance and participation in classes	50%	**15%**
Individual study	Task 1: Classification of research by activity type	Presentation/Discussion on the topic	50%	**15%**
	Task 2: Developing a scientific article	Article presented for evaluation	50%	
Final evaluation	Theoretical and practical content	Oral exam. Grading according to grading scale	100%	**40%**