ÓBUDA UNIVERSITY
JOHN VON NEUMANN FACULTY OF INFORMATICS

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2023-24-1</td></tr>
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Course description

Goal:	To review and organize knowledge of linear algebra at the MSc level; development of the student's conceptualisation, abstraction and problem-solving abilities by getting to know the basic topics of linear algebra, as well as their applications in problem solving and model creation.
Course description:	Fields, the general concept of a vector space, basic definitions. Systems of linear equations, matrices, determinants. Matrix decompositions, eigenvalues, diagonalizability, Spectral theorem, SVD. Classification of Euclidean and unitary spaces, bilinear forms, quadratic forms. Perron-Frobenius theorem.

Lecture schedule

Education week	Topic
1.	Notion of field and vector space; linear independence, generating system, basis.
2.	Linear transformations, transformation matrix, kernel and image.
3.	Systems of linear equations, Gaussian elimination, rank decomposition.
4.	Elementary matrices, LU decomposition, fundamental subspaces, pseudo inverse.
5.	Eigenvalues, eigenvectors, algebraic and geometric multiplicities, diagonalizability.
6.	Real spectral theorem. Generalised eigenspaces, Jordan canonical form.
7.	1^{st} midterm test.
8.	Euclidean spaces, orthogonalization QR decomposition.
9.	Singular value decomposition.
10.	Unitary spaces, orthogonalization, SVD in unitary spaces.
11.	Bilinear and quadratic forms, Sylvester's law of inertia, definiteness.
12.	Positive matrices, Perron theorem.
13.	2^{nd} midterm test.
14.	Test retake.

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	50% of the midterms in average

Assessment schedule

Education week	Topic
7.	Material covered during the first six education weeks
13.	Material covered during education weeks 7 to 12
14.	Material of either of the midterm tests

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Based upon the sum of the scores reached at the midterm test:
0-49%: fail

	50-61%: pass 62-73%: satisfactory 74-85%: good 86-100%: excellent
Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	In the last week of the period either of the midterm tests can be rewritten. In case of failure, the mid-term grade can be acquired in the grade-retake exam held during the first 10 days of the examination period.
Type of the exam (to be filled out only for subjects with exams)	
Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
References	
Obligatory:	Carl. D. Meyer: Matrix analysis and applied linear algebra, SIAM (Society for Industrial and Applied Mathematics) Press, Philadelphia, 2000, ISBN 0-89871-454-0 A.J. Laub: Matrix Analysis for Scientists and Engineers, SIAM, 2005 S. Axler: Linear Algebra Done Right, 2nd ed., Springer, 1997
Recommended:	D. Cherney, T. Denton, A. Waldron: Linear algebra
Other references:	Material uploaded to the e-learning system of the university

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Institute of Applied Mathematics			Semester 1. of the curriculum 2023-24-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Algebra and number theory	NMXAS1EMNF	4	full-time	2	0	0
Responsible person for the subject: Dr. SZŐKE Magdolna			Classification: senior lecturer			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	Acquirement of basic algebraic and number theoretic notions and theorems, their application in exercises.
Course description:	Operations, algebraic structures, concept of semigroup. Basics of group theory, examples of groups: cyclic, dihedral, symmetric and linear groups. Lagrange theorem, normal subgroups, factor groups, homomorphism theorem. Sylow theorems. Direct products, fundamental theorem of finite Abelian groups; simple groups. Basics of ring theory: subrings, ideals, factor rings. Integral domains, principal ideal domains, fields. Basics of number theory in integral domains, Euclidean domains. Basic concepts of Lie algebra, examples.

Lecture schedule	
Education week	Topic
1.	Properties of operations, notion of semigroup.
2.	Notion of group, examples. Subgroups, Lagrange’s theorem.
3.	Normal subgroups, factor groups, homomorphism theorem.
4.	Conjugacy classes, centraliser, centre.
5.	Sylow's theorems.
6.	Direct product, fundamental theorem of finite Abelian groups.
7.	Notion of simple group, examples.
8.	Notion of ring; subrings, ideals, factor rings.
9.	Integral domains, principal ideal domains, fields.
10.	Elements of number theory in integral domains.
11.	Euclidean algorithms, Euclidean domains.
12.	Notion of Lie algebra, examples. Lie subalgebras, ideals, factor algebras.
13.	Midterm test
14.	Test retake

Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	To gain at least 50% of the scores at the midterm test.

Assessment schedule	
Education week	Topic
13.	The material of the whole term
14.	Same

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	The signature can be acquired in the signature retake exam (during the first 10 days of the examination period).
Type of the exam (to be filled out only for subjects with exams)	
Oral	
Calculation of the exam mark (to be filled only for subjects with exams)	
30% from the midterm test, 70% from the oral exam	
Final grade calculation methods:	
0-49%: fail 50-61%: pass 62-73%: satisfactory 74-85%: good 86-100%: excellent	
References	
Obligatory:	D. S. Dummit and R. M. Foote: Abstract algebra, Wiley, 2004.
Recommended:	
Other references:	Lecture notes uploaded to the e-learning system of the university

Institute of Applied Mathematics			Semester 1. of the curriculum 2023-24-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Analysis	NMXAN1EMNF	4	full-time	2	1	0
Responsible person for the subject: Dr. VAJDA István			Classification: senior lecturer			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	mid-term grade					

Course description

Goal:	Our goal is to introduce the fundamental concepts of functional analysis and Lebesgue integration. These concepts are crucial in the modern study of probability theory, (partial) differential equations, and quantum theory, for instance.
Course description:	The problem of the measure. Lebesgue integral, convergence theorems. Lebesgue and Riemann integrals. Study of Hilbert spaces with orthogonal systems, duality.

Lecture schedule

Education week	Topic
1.	Introduction to measure theory
2.	Exterior measure and Lebesgue measure of $\mathbb{R}^d$
3.	Measurable functions and their properties
4.	Lebesgue integral
5.	Convergence theorems: Fatou lemma, Monotone convergence theorem and Lebesgue's dominated theorem
6.	1^{st} midterm exam
7.	General measures and the Lebesgue Lp-spaces
8.	Differentiation: absolute continuous functions
9.	Functions of bounded variations
10.	Introduction to Hilbert spaces, normed spaces
11.	Geometry of Hilbert spaces, inner product spaces
12.	Duality, orthogonal basis of L2 spaces, integral operators, kernels
13.	2^{nd} midterm exam
14.	Resit exam

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	One needs to accomplish at least 50% of the weekly home assignments. There will be two written midterms.

Assessment schedule

Education week	Topic
6.	Material of the first 5 education weeks
13.	Material covered after the first midterm
14.	One of the above

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Achieved result	Grade

89%-100%	excellent (5)
76%-88<%	good (4)
63%-75<%	satisfactory (3)
51%-62<%	pass (2)
0%-50<%	fail (1)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	At the last week of the semester one can have a resit exam. In the first ten days of the examination period, there is a midterm grade retake exam.

Type of the exam (to be filled out only for subjects with exams)

Calculation of the exam mark (to be filled only for subjects with exams)

Final grade calculation methods:

References	
Obligatory:	E. Stein: Real Analysis
Recommended:	Rynne and Youngson: Linear Functional Analysis
Other references:	

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Institute of Applied Mathematics			Semester 1. of the curriculum 2023-24-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Geometry and topology	NMXGT1EMNF	4	full-time	2	1	0
Responsible person for the subject: Prof. Dr. NAGY Péter Tibor			Classification: professor emeritus			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	Acquisition of geometric, differential geometric and topological knowledge required for geometric modelling.
Course description:	Isometries of the Euclidean plane and space. The geometry of the sphere, elliptic plane, projective plane, hyperbolic plane. Euler polyhedron theorem, regular polyhedra. Topology of surfaces, Euler characteristic. Differentiable curves, curvature and torsion. Topological and metric spaces, sequences and convergence, compactness and connectedness.

Lecture schedule

Education week	Topic
1.	Isometries of the Euclidean plane. Classification.
2.	Isometries of the Euclidean space. Classification.
3.	Geometry of the sphere, elliptic plane.
4.	Projective plane, Beltrami–Klein and Poincaré disk model of hyperbolic plane.
5.	Euler polyhedron theorem, Euler characteristic.
6.	Regular polyhedral, constructions and classification.
7.	1st midterm
8.	Differentiable curves, curvature.
9.	Torsion, Frenet equations.
10.	Topological and metric spaces.
11.	Sequences and convergence.
12.	Compactness and connectedness
13.	2nd midterm
14.	Summary, evaluation

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	50% of home assignments

Assessment schedule

Education week	Topic
7	1st midterm: 1-6 weeks
13	2nd midterm: 8-12 weeks
14	test retake

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	Written exam
Type of the exam (to be filled out only for subjects with exams)	
Written and oral exam	
Calculation of the exam mark (to be filled only for subjects with exams)	
70% written exam + 30% oral exam	
Final grade calculation methods:	
0-50: fail (1) 51-62: pass (2) 63-75: satisfactory (3) 76-88: good (4) 89-100: excellent (5)	
References	
Obligatory:	Audin, Michèle; Geometry, Universitext, Springer, 2003.
Recommended:	Coxeter, H.S.M.; Introduction to Geometry, Wiley, 1969. Hoffmann Miklós: Topology and differential geometry, https://dtk.tankonyvtar.hu/xmlui/handle/123456789/8413
Other references:	

Institute of Applied Mathematics			Semester 1. of the curriculum 2023-24-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Probability theory and mathematical statistics	NMXVS1EMNF	4	full-time	2	1	0
Responsible person for the subject: Dr. KÁRÁSZ Péter			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	To lay the foundations of probability theory and statistics
Course description:	Kolmogorov probability space; law of total probability; conditional probability; Bayes' theorem; probability distribution function; expectation, variance and moments; special distributions (Poisson, uniform, etc.). Moment generating function, characteristic function. Joint distributions; random vectors; independence; covariance matrix. General definition and properties of conditional expectation; law of total expectation. Types of convergence; Borel-Cantelli lemmas; laws of large numbers; sums of random variables; central limit theorems. Statistical space; sample; statistics; ordered sample; empirical distribution function; Glivenko-Cantelli theorem. Estimation techniques, maximum-likelihood estimation, method of moments, method of least squares. Hypothesis testing; confidence intervals. Parametric and nonparametric tests.

Lecture schedule	
Education week	Topic
1.	Kolmogorov probability space and related notions. Examples.
2.	Law of total probability; conditional probability, Bayes' theorem. Random variables and their properties. Probability distribution function; expectation, variance and moments
3.	Special discrete and continuous random variables and their properties (Poisson, uniform distributions, etc.)
4.	Continuation of lecture 3 plus moment generating functions, characteristic function
5.	Joint distributions; random vectors; independence; covariance matrix.
6.	General definition and properties of conditional expectation; law of total expectation.
7.	Types of convergence; Borel-Cantelli lemmas; laws of large numbers; sums of random variables; central limit theorems.
8.	Continuation of lecture 7.
9.	Statistical space; sample; statistics; ordered sample; empirical distribution function; Glivenko-Cantelli theorem.
10.	Continuation of lecture 9.
11.	Estimation techniques, maximum-likelihood estimation, method of moments, method of least squares.
12.	Hypothesis testing; confidence intervals
13.	Parametric and nonparametric tests

14.	Summary

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	written exam

Assessment schedule

Education week	Topic
7.	First 6 weeks
14.	8-13 weeks

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	cf. TVSZ

Type of the exam (to be filled out only for subjects with exams)

Written exam.

Calculation of the exam mark (to be filled only for subjects with exams)

Final grade calculation methods:

Achieved result	Grade
89%-100%	excellent (5)
76%-88<%	good (4)
63%-75<%	satisfactory (3)
51%-62<%	pass (2)
0%-50<%	fail (1)

References

Obligatory:	https://www.math.ucdavis.edu/~gravner/MAT135A/resources/lecturenotes.pdf
Recommended:	Gut, A.: An Intermediate Course of Probability, 2nd ed.; Springer; 2009. Gut, A.: Probability: A Graduate Course; Springer; 2005.
Other references:	

Software Engineering Institute			Semester 1. of the curriculum 2023-24-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Introduction to MATLAB programming	NSXBM1EMNF	4	full-time	0	0	2
Responsible person for the subject: Dr. SERGYÁN Szabolcs			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	mid-term grade					

Course description

Goal:	Acquiring the fundamental knowledge and applications related to MATLAB. It serves the dual purpose of teaching computer programming and providing a background in MATLAB.
Course description:	Variables, arrays, vectors and matrices; MATLAB functions, loops, decisions in MATLAB. Linear algebra with MATLAB; basics of 2-D plots, data visualization: frequencies, bar charts and histograms. File input/output operations.

Lecture schedule

Education week	Topic
1.	Introduction to MATLAB: variables and the workspace
2.	Arrays: vectors and matrices
3.	Operators, expressions and statements
4.	Functions
5.	Loops, repeating with *for*
6.	Decisions, selections
7.	1st midterm exam
8.	File input/output
9.	Elements of linear algebra with MATLAB
10.	Advanced matrix operations
11.	Introduction to graphics: 2-D graphs
12.	Frequencies, bar charts and histograms
13.	2nd midterm exam
14.	Summary, evaluation

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	Two midterms.

Assessment schedule

Education week	Topic
7	Elements of MatLab
13	Linear algebra and basic graphics
14	Rewriting a classroom test

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

89-100%: excellent (5)
76-88%: good (4)
63-75%: satisfactory (3)
51-62%: pass (2)
0-50%: fail (1)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	One of the midterms can be replaced in the final week.
Type of the exam (to be filled out only for subjects with exams)	
Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
References	
Obligatory:	J. Michael Fitzpatrick, Á. Lédeczi - Computer Programming with MATLAB, ebook, 2013.
Recommended:	B. Hahn and D. Valentine, Essential MATLAB for Engineers and Scientists, Elsevier, 2002.
Other references:	

Institute of Applied Mathematics			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Algorithm theory	NMXAE1EMNF	4	full-time	3	0	0
Responsible person for the subject: Dr. HEGEDÜS Gábor			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	Developing the student's conceptualization, abstraction, and problem-solving abilities by learning about the basic topics of algorithm theory as well as their applications in problem solving and model creation. The basic concepts of graph algorithms and complexity theory are learned.
Course description:	Dynamical programming, graph algorithms: BFS, DFS, maximal matching in bipartite graphs, Bellman-Ford's, Floyd's, Dijkstra's algorithm, sorting: insertion sort, bubble sort, shell sort, merge sort, quick sort, bucket and radix sort, binary search tree, 2-3 tree, B tree, Jarnik-Prim's algorithm, Kruskal's algorithm, P, NP, coNP classes and their connections, NP-completeness

Lecture schedule

Education week	Topic
1.	Ordo, omega, theta, branch and bound, dynamical programming (binomial coefficients, backpack)
2.	Graphs, breadth first search, depth first search, maximal matching in bipartite graphs
3.	Bellman-Ford's, Floyd's, Dijkstra's algorithms
4.	Searching (linear, binary), sorting: insertion sort, bubble sort, shell sort
5.	Sorting: shell sort, merge sort, bucket and radix sort
6.	First midterm test
7.	Topological order, dag, searching of the shortest and longest paths in dags, strong connectivity of graphs
8.	Binary search tree, 2-3 tree, B tree, AVL tree
9.	Minimal spanning trees: Kruskal's and Prim's algorithm
10.	Decision problems, P, NP and coNP classes
11.	Basic properties of Karp reduction
12.	NP-completeness, NP-complete problems
13.	Second midterm test
14.	Test retake

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	The student obtains the signature only if they have written both midterm test and reach at least 50% of the scores. The midterm tests consist of theoretical questions and exercises from the material of the lectures and

	classes. It is compulsory to attend the lectures and classes, the absence may not exceed 30% of the lectures.

Assessment schedule

Education week	Topic
6.	Material of weeks 1 to 5
13.	Material of weeks 7 to 12
14.	One of the midterms

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	Test retake in the last week of the lecture period, signature retake exam in the first 10 days of the examination period.

Type of the exam (to be filled out only for subjects with exams)

Written exam consisting of theoretical and practical parts.

Calculation of the exam mark (to be filled only for subjects with exams)

50% for theoretical questions and 50% for exercises

Final grade calculation methods:

Total points	**Colloquium grade**
86–100	excellent (5)
74–85	good (4)
62–73	satisfactory (3)
50–61	pass (2)
0–49	fail (1)

References

Obligatory:	Materials uploaded to the e-learning system of the university
Recommended:	R. Sedgewick, K. Wayne: Algorithms Herbert S. Wilf: Algorithms and Complexity
Other references:	

Institute of Applied Mathematics			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Discrete mathematics	NMXDM1EMNF	4	full-time	2	1	0
Responsible person for the subject: Dr. HEGEDÜS Gábor			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	Developing the student's conceptualization, abstraction, and problem-solving abilities by learning about the basic topics of discrete mathematics, as well as their applications in problem solving and model creation. The basic concepts of graph algorithms and complexity theory are learned from the theory of algorithms.
Course description:	Principle of mathematical induction, pigeonhole principle, principle of inclusion and exclusion. Permutations, variations and combinations, binomial theorem. Generating functions and their basic properties. Linear recurrence relations, Stirling, Catalan, Bell and Fibonacci sequences. The basic properties of graphs, subgraphs, complements and graph isomorphism. Trees, forests, Prüfer code, Euler trails and circuits, Hamilton paths and cycles, Ore's theorem, Posa's theorem, extreme graph theory, Turán's theorem. Graph colouring, Brooks' theorem, Vizing's theorem, perfect graphs, planar graphs, dual graphs, Kuratowski's theorem. Matching theory, Hall's theorem, König's theorem, Gallai's theorem, Hungarian method, flows, max-flow min-cut theorem.

Lecture schedule

Education week	Topic
1.	Principle of mathematical induction, pigeonhole principle, principle of inclusion and exclusion
2.	Permutations, variations and combinations, binomial theorem
3.	Generating functions and their basic properties
4.	Linear recurrence relations
5.	Stirling, Catalan, Bell and Fibonacci sequences
6.	First midterm test
7.	The basic properties of graphs, subgraphs, complements and graph isomorphism
8.	Trees, forests, Prüfer code
9.	Euler trails and circuits, Hamilton path and cycles, Ore's theorem, Posa's theorem, extreme graph theory, Turán's theorem
10.	Vertex colouring, Brooks' theorem, Vizing's theorem
11.	Perfect graphs, planar graphs, dual graphs, Kuratowski's theorem
12.	Matching theory, Hall's theorem, König's theorem, Gallai's theorem, Hungarian method, flows, max-flow min-cut theorem
13.	Second midterm test
14.	Test retake

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	The student obtains the signature only if they have written both midterm test and reach at least 50% of the scores. The midterm tests consist of theoretical questions and exercises from the material of the lectures and classes. It is compulsory to attend the lectures and classes, the absence may not exceed 30% of the lectures.

Assessment schedule	
Education week	Topic
6.	Material of weeks 1 to 5
13.	Material of weeks 7 to 12
14.	One of the midterms

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	Test retake in the last week of the lecture period, signature retake exam in the first 10 days of the examination period

Type of the exam (to be filled out only for subjects with exams)

Written exam

Calculation of the exam mark (to be filled only for subjects with exams)

50% for theoretical questions and 50% for exercises

Final grade calculation methods:

Total points	**Colloquium grade**
86–100	excellent (5)
74–85	good (4)
62–73	satisfactory (3)
50–61	pass (2)
0–49	fail (1)

References

Obligatory:	Materials uploaded to the e-learning system of the university
Recommended:	Graham, Ronald L., Donald E. Knuth, and Oren Patashnik: *Concrete Mathematics*, Massachusetts: Addison-Wesley Grimaldi, Ralph P.: *Discrete and Combinatorial Mathematics, 5/e*. Pearson Education India, 2003.
Other references:	

Software Engineering Institute			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Interpolation and approximation	NSXIA1EMNF	4	full-time	2	0	0
Responsible person for the subject: Prof. Dr. GALÁNTAI Aurél			Classification: professor emeritus			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description

Goal:	The aim of the course is getting to know the basic interpolation and approximation techniques and results.
Course description:	Univariate and multivariate Interpolation. Lagrange interpolation and its convergence. Spline interpolation. Chebyshev approximation by polynomials and rational functions. Padé approximation. Least squares approximation. Fourier approximation.

Lecture schedule

Education week	Topic
1.	Introduction
2.	Interpolation I.
3.	Interpolation II.
4.	Interpolation III.
5.	Spline interpolation I.
6.	Spline interpolation II.
7.	Spline interpolation III.
8.	Chebyshev approximation I.
9.	Chebyshev approximation II.
10.	Chebyshev approximation III.
11.	Rational approximation, Padé approximation, Applications
12.	Least squares approximation of real functions
13.	Fourier series I.
14.	Fourier series II.

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	The assignments issued at education week 6 must be completed and submitted until the end of week 14. Acceptance of the assignments is the condition of the signature.

Assessment schedule

Education week	Topic

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	Assignments not submitted or not accepted can be resubmitted until day 10 of the examination period.

Type of the exam (to be filled out only for subjects with exams)
Oral exam.
Calculation of the exam mark (to be filled only for subjects with exams)
The assessment is based on the performance of the oral exam.
Final grade calculation methods:

References	
Obligatory:	Lecture slides
Recommended:	J.H. Ahlberg, E.N. Nilson, The theory of splines and their applications, Academic Press, 1967 J. Bustamante, Algebraic approximation: A Guide to Past and Current Solutions, Birkhäuser, 2012 E.W. Cheney, Introduction to approximation theory, AMS Chelsea Publishing, 2000 P.J. Davis, Interpolation and approximation, Dover, 1975 G.G. Lorentz, Approximation of functions, AMS Chelsea Publishing, 2005 G. Mastroianni, G.V. Milovanovic, Interpolation Processes, Basic Theory and Applications, Springer, 2008 T.J. Rivlin, An introduction to the approximation of functions, Dover, 1981
Other references:	

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Institute of Applied Mathematics			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Differential equations	NMXDE1EMNF	4	full-time	2	1	0
Responsible person for the subject: Prof. Dr. TAKÁCS Márta			Classification: professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	To provide an overview of the fundamental concepts of planar dynamical systems. Moreover, the course discusses the methods of calculus of variations with applications in mechanics, and elements of PDEs (heat and wave equations in Euclidean spaces).
Course description:	Dynamics of first and second order differential equations, stability of fixed points through linearization. Energy methods and Lyapunov direct methods. Periodic solutions, limit cycles. Calculus of variations. Hamiltonian and Lagrangian systems, Legendre transform. Elements of PDEs: method of characteristics, heat equation, wave equation.

Lecture schedule	
Education week	Topic
1.	First-order ordinary differential equations: linear, exact and separable systems
2.	Dynamics of first order autonomous differential equations, fixed points.
3.	Dynamics of second order systems: Jacobian matrix, characterization of fixed points through linearization, stability
4.	Energy methods, Lyapunov s theorems on stability
5.	Periodic solutions, limit cycles: divergence criterion, Poincaré-Bendixson theorem
6.	1st written exam
7.	Introduction to variational calculus: brachistochrone problem, Euler-Lagrange equations
8.	Calculus of variations in mechanics, Hamiltonian systems
9.	Hamiltonian and Lagrangian systems, Legendre transformation
10.	Partial differential equations: method of characteristics
11.	Second order partial differential equations, classification
12.	Laplace operator, Dirichlet energy and the heat equation
13.	2nd written exam
14.	Goursat- and Cauchy problems, the wave equation.

Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	50% weekly home assignments in each actual topic, two midterms.

Assessment schedule	
Education week	Topic
7	1st midterm exam
13	2nd midterm exam
14	Resit exam

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	Resit exam on the last week
Type of the exam (to be filled out only for subjects with exams)	
Final written exam of 180 mins	
Calculation of the exam mark (to be filled only for subjects with exams)	
30 % home assessments + 70 % final exam	
Final grade calculation methods:	
0-50 fail (1) 51-62 pass (2) 63-75 satisfactory (3) 76-88 good (4) 89- excellent (5)	
References	
Obligatory:	R. Kent Nagle, Edward B. Saff, Arthur David Snider: Fundamentals of Differential Equations and Boundary Value Problems, 8th Edition, Addison-Wesley, 2011.
Recommended:	D. Strogatz: Non-linear dynamics and chaos, Westview Press, 2001.
Other references:	E. Lieb, M. Loss: Analysis, Amer. Math. Soc., Providence, 2001.

Institute of Applied Mathematics			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:	lec	sem	lab
Stochastic processes and applications	NMXH S1EMN F	5	full-time	2	2	0
Responsible person for the subject: Dr. KÁRÁSZ Péter			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description

Goal:	To lay the foundations of stochastic processes and give applications of the theory.
Course description:	Notion of stochastic processes. Discrete Markov chains: classification of states, limiting probabilities, applications. Continuous Markov chains, Poisson processes, Renewal processes, birth and death processes. Queueing theory. Martingales. Further applications.

Lecture schedule

Education week	Topic
1.	Basic examples of stochastic processes.
2.	Markov Chains: Introduction.
3.	Markov Chains: Classification of States.
4.	Branching processes.
5.	Markov Chains: Limiting Probabilities.
6.	Markov Chains: Reversibility.
7.	Continuous Time Markov Chains.
8.	Poisson Processes.
9.	Renewal Processes.
10.	Birth-death Processes.
11.	Queueing Theory.
12.	Martingales.
13.	Further applications.
14.	Summary

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	Written exam

Assessment schedule

Education week	Topic
7.	First 6 weeks
14.	Weeks 8 to 13

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	cf. TVSZ

Type of the exam (to be filled out only for subjects with exams)

Written exam

Calculation of the exam mark (to be filled only for subjects with exams)

Final grade calculation methods:

Achieved result	Grade
89%-100%	excellent (5)
76%-88<%	good (4)
63%-75<%	satisfactory (3)
51%-62<%	pass (2)
0%-50<%	fail (1)

References

Obligatory:	S. Karlin, H. M. Taylor: A First Course in Stochastic Processes
Recommended:	Janko Gravner: Lecture Notes for Introductory Probability. https://www.math.ucdavis.edu/~gravner/MAT135A/resources/lecturenotes.pdf Rick Durrett: Essentials of Stochastic Processes. Springer, 2010.
Other references:	

Institute of Applied Mathematics			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Optimization methods	NMXOM1EMNF	5	full-time	2	2	0
Responsible person for the subject: Prof. Dr. TAKÁCS Márta			Classification: professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	exam					

Course description	
Goal:	The subject presents the most important methods of optimization problems, which can be used on economy, industrial, scientific area
Course description:	Operational methods, Geometry of linear programming, simplex method, duality, integer programming, network optimization, Game theory

Lecture schedule	
Education week	Topic
1.	Operational research, optimization
2.	Geometry of linear programming
3.	Simplex method 1.
4.	Simplex method 2.
5.	Duality 1.
6.	Duality 2.
7.	1st midterm
8.	Integer programming 1.
9.	Integer programming 2.
10.	Network optimization 1.
11.	Network optimization 2.
12.	Game theory
13.	2nd midterm
14.	Retake

Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	50% of the midterms in average

Assessment schedule	
Education week	Topic
7	Weeks 1-6
13	Weeks 8-12
14	Test retake

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	Retake of the midterm on week 14.

Type of the exam (to be filled out only for subjects with exams)

Written exam	
Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
0-49%: fail (1) 50-61%: pass (2) 62-73%: satisfactory (3) 74-85%: good (4) 86-100%: excellent (5)	
References	
Obligatory:	Dimitris Bertsimas, John N. Tsitsiklis: Introduction to Linear optimization
Recommended:	
Other references:	

Institute of Applied Mathematics			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Fourier analysis and series	NMXFA1EMNF	4	full-time	2	0	0
Responsible person for the subject: Prof. Dr. TAR József			Classification: professor			
Subject lecturer(s):						
Prerequisites:	NMXAN1EMNF	Analysis				
Way of the assessment:	exam					

Course description

Goal:	Acquiring the foundations and applications related to Fourier analysis
Course description:	Fourier expansion of periodic functions, convergence of Fourier series. Hilbert space and its orthonormal basis. Fourier method and its application to PDEs, boundary value problems. Wavelets. Fourier transform, inversion formula and PDEs.

Lecture schedule

Education week	Topic
1.	Fourier expansion of periodic functions
2.	Fourier expansion of even and odd functions, examples
3.	Convergence of Fourier series, Dirichlet and Fejér kernel
4.	Hilbert space of square integrable functions
5.	Least-squares approximation in Hilbert spaces
6.	Orthogonal functions, Parseval formula
7.	1st midterm
8.	Fourier method and the heat equation
9.	Fourier method and the wave equation
10.	Fourier transform on the real line
11.	Fourier inversion formula, Plancherel theorem
12.	Heat equation on the real line
13.	2nd midterm
14.	Summary, evaluation

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	**50% home assignments**

Assessment schedule

Education week	Topic
7	1st midterm: 1-6 weeks
13	2nd midterm: 8-12 weeks
14	Resit exam

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

-

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	Written exam

Type of the exam (to be filled out only for subjects with exams)

Written exam of 120 mins	
Calculation of the exam mark (to be filled only for subjects with exams)	
0-50 fail (1) 51-62 pass (2) 63-75 satisfactory (3) 76-88 good (4) 89-100 excellent (5)	
Final grade calculation methods:	
30% midterms + 70% exam	
References	
Obligatory:	A. Vretblad, Fourier Analysis and Its Applications, Springer, 2003
Recommended:	N. Ashmar, Partial Differential Equations with Fourier series and Boundary Value Problems, 3rd Edition, Dover Books, 2016
Other references:	-

Software Engineering Institute			Semester 3. of the curriculum 2024-25-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Engineering computational methods	NSXMS1EMNF	5	full-time	2	0	2
Responsible person for the subject: Prof. Dr. GALÁNTAI Aurél			Classification: professor emeritus			
Subject lecturer(s):						
Prerequisites:	NMXDE1EMNF	Differential equations				
Way of the assessment:	exam					

Course description	
Goal:	Study of numerical methods for differential equations.
Course description:	Solution of linear and nonlinear system of equations. Methods for ODE IVP and BVP. Their programming, convergence and stability. Discretizations of PDE. Variational methods. Ritz and Galerkin methods. FEM. Matlab programming and Matlab programs.

Lecture schedule	
Education week	Topic
1.	The elements of Matlab
2.	Direct solution methods of linear systems 1
3.	Direct solution methods of linear systems 2
4.	Solution methods of nonlinear equations
5.	Discretization methods of ODE IVPs 1
6.	Discretization methods of ODE IVPs 2
7.	Discretization methods of ODE BVPs 1
8.	Discretization methods of ODE BVPs 2
9.	Solution methods for PDEs 1
10.	Solution methods for PDEs 2
11.	Solution methods for PDEs 3
12.	Solution methods for PDEs 4
13.	Matlab ODE programs
14.	Examples

Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	Solving a minimum of 40% of the individual test problems given during the semester.

Assessment schedule	
Education week	Topic

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	Submission of the individual test problems can be repeated during the first 10 days of the examination period.

Type of the exam (to be filled out only for subjects with exams)	
Oral exam.	
Calculation of the exam mark (to be filled only for subjects with exams)	
The assessment is based on the performance at the oral exam.	
Final grade calculation methods:	
References	
Obligatory:	A. Galántai A.: Engineering Computational Methods 1 2014/2015 spring semester (lecture notes)
Recommended:	U.M. Ascher, R.M.M. Mattheij, R.D. Russell, Numerical Solution of Boundary Value Problems for Ordinary Differential Equations, SIAM, 1995 S.C. Brenner, L. Ridgway Scott, The Mathematical Theory of Finite Element Methods, 3rd ed., Springer, 2008 C.G. Broyden, M.T. Vespucci, Krylov Solvers for Linear Algebraic Systems, Elsevier, 2004
Other references:	

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Biomatics and Applied Artificial Intelligence Institute			Semester 3. of the curriculum 2024-25-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Multivariate statistical methods	NBXTS1EMNF	4	full-time	2	0	2
Responsible person for the subject: Dr. habil. FERENCI Tamás			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:	NMXVS1EMNF	Probability theory and mathematical statistics				
Way of the assessment:	exam					

Course description

Goal:	
Course description:	Multidimensional distribution, multidimensional normal distribution, conditional distributions, Wishart distribution, Cochran-Fisher theorem. ML estimation of the parameters of the multidimensional normal distribution, hypothesis testing of the parameters. Multidimensional regression analysis, variance analysis, covariance analysis, principal component, and factor analysis. Analysis of contingency tables, discriminant analysis, cluster analysis, multidimensional scaling and embedding. Multivariate threshold models, probit and logit analysis. Multivariate statistical software packages.

Lecture schedule

Education week	Topic
1.	Univariate probability theory
2.	Univariate statistical inference
3.	Multivariate normal distribution
4.	Inference and hypothesis testing in the multivariate normal model I.
5.	Inference and hypothesis testing in the multivariate normal model II.
6.	Test 1
7.	Introduction to regression
8.	Linear regression and its extensions I.
9.	Linear regression and its extensions II.
10.	Linear regression and its extensions III.
11.	Logistic regression
12.	Generalized linear models
13.	Advanced topics
14.	Test 2

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	

Assessment schedule

Education week	Topic
6	Test 1
14	Test 2
14	Test retake

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement		
Type of the replacement of written test/mid-term grade/signature		
Type of the exam (to be filled out only for subjects with exams)		
Calculation of the exam mark (to be filled only for subjects with exams)		
Final grade calculation methods:		
References		
Obligatory:	B. Flury: A First Course in Multivariate Statistics, Springer, 1997 K.V. Mardia, J.T. Kent and J.M. Bibby: Multivariate Analysis, Academic Press, 1979 C. R. Rao: Linear statistical inference and its applications, Wiley and Sons, 1968	
Recommended:		
Other references:		

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Institute of Applied Mathematics			Semester 4. of the curriculum 2024-25-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
System and control theory	NMXSC1EMNF	5	full-time	2	0	2
Responsible person for the subject: Prof. Dr. TAR József			Classification: professor			
Subject lecturer(s):						
Prerequisites:	NMXDE1EMNF	Differential equations				
Way of the assessment:	exam					

Course description

Goal:	The aim of this course is to provide the students with the fundamental classical knowledge of control technology and to consider certain modern approaches.
Course description:	Model Predictive Controller (MPC): optimization under constraints, Lagrange multipliers, reduced gradient, auxiliary function, nonlinear programming. The heuristic Receding Horizon Control. Simulation issues: MS EXCEL – Solver, legally free alternatives of MATLAB: Julia language. General description of the LTI systems: stability, observability, controllability. The method of "Pole Placement". State estimation by the Luenberger Observer. MPC for LTI models and quadratic cost functions: the LQR regulator. Tackling the LTI systems in the frequency domain: basics in Distribution Theory: the function class D and its use for classical modelling. Singular Value Decomposition (SVD), the H_∞ norm, robust design, the "minimax" principle. Robust nonlinear controller: the Sliding Mode / Variable Structure Controller. Adaptive controllers: the "kappa" function class, Lyapunov's "stability", "uniform stability", and "asymptotic stability" definitions, quadratic Lyapunov functions, Control Lyapunov function, Backstepping Control, the "Adaptive Inverse Dynamics Robot Controller".

Lecture schedule

Education week	Topic
1.	Model Predictive Controller (MPC): realization on a finite time-grid: the Receding Horizon Controller optimization under constraints, Lagrange multipliers, reduced gradient, auxiliary function, nonlinear programming.
2.	The continuous case: minimization of functionals, dynamic programming; Special case: the LQR regulator.
3.	Simulation issues: MS EXCEL – Solver, legally free alternatives of MATLAB: Julia language.
4.	General description of the LTI systems: stability, observability, controllability.
5.	Luenberger observer; Special cases for a single variable control signal: Lyapunov function, Control Lyapunov Function, Pole Placement.
6.	Tackling the LTI systems in the frequency domain: basics in Distribution Theory: the function class D and its use for classical modelling. Singular Value Decomposition (SVD), the H_∞ norm, robust design, the "minimax" principle.
7.	Control of strongly nonlinear systems: Lyapunov's "direct method", functions of class "kappa", quadratic Lyapunov functions, stability definitions; Control Lyapunov function.
8.	Quadratic Lyapunov functions; Backstepping design for the control of hierarchical systems.
9.	The Robust Variable Structure/Sliding Model Controller.
10.	Lyapunov function-based adaptive control: example: the Adaptive Inverse Dynamics Controller.
11.	Alternatives of the Lyapunov function-based adaptive control design: Fixed Point Iteration-based Adaptive Control, Banach's Theorem.

12.	Fixed Point iteration-based Model Reference Adaptive Control.
13.	Consultations for the course work submission.
14.	Consultations for the course work submission.

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	Student participation in the lectures and labs is required. All homeworks and the classroom test are required to be completed during the term.

Assessment schedule

Education week	Topic
By the end of the term	Submission of simulation program developed by the students with documented results.

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	Prompt elaboration of a control simulation.

Type of the exam (to be filled out only for subjects with exams)

Oral examination (classical colloquium)

Calculation of the exam mark (to be filled only for subjects with exams)

Final grade calculation methods:

References

Obligatory:	Free of charge available lecture notes in PDF and the programming aids with which the students are provided during the course.
Recommended:	Kemin Zhou, John C. Doyle, Keith Glover: *Robust and Optimal Control*, Pearson; 1 edition, 1995. J. K. Tar, L. Nádai, I. J. Rudas: *System and Control Theory with Especial Emphasis on Nonlinear Systems*, TYPOTEX, Budapest, 2012, ISBN 978-963-279-676-5
Other references:	

Institute of Applied Mathematics			Semester 3. of the curriculum 2024-25-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Partial differential equations	NMXPD1EMNF	6	full-time	2	0	2
Responsible person for the subject: Prof. Dr. TAKÁCS Márta			Classification: professor			
Subject lecturer(s):						
Prerequisites:	NMXDE1EMNF	Differential equations				
Way of the assessment:	exam					

Course description

Goal:	Introduction to the theory of PDEs and their solving methods with the help of generalized functions (distributions).
Course description:	Initial and boundary value problems for hyperbolic and parabolic equations, weak solutions to elliptic boundary problems, Generalized functions, Bessel functions, fundamental solutions, Cauchy problems.

Lecture schedule

Education week	Topic
1.	First-order equations, linear in their principal parts.
2.	Classification of second-order PDEs, linear in their principal parts in two variables. The wave operator and the first-order Klein-Gordon operator.
3.	The heat operator, the Laplace operator and the Helmholtz operator. The Cauchy-Riemann operator and the Schrödinger operator. The Bernoulli-Euler beam operator. Initial and boundary value problems for hyperbolic equations.
4.	Initial and boundary value problems for parabolic equations. Elliptic boundary problems.
5.	Metric and topological spaces.
6.	Topological vector spaces. Locally integrable functions, ground functions. Generalized functions (distributions).
7.	Singular distributions. Derivatives of distributions. Multiplication by a smooth function. Direct product of distributions.
8.	Convolutions of functions and distributions.
9.	Rapidly decreasing and slowly increasing functions and distributions. Fourier transforms of functions. Inhomogeneous linear coordinate transformation of distributions.
10.	Fourier transforms of distributions. Fundamental solutions, particular solutions to inhomogeneous equations.
11.	Fundamental solutions to ordinary linear differential operators with constant coefficients. Fundamental solutions to first-order PDEs. Fundamental solutions to the heat operator, the wave operator and the one-dimensional Klein-Gordon operator. Bessel functions of order 0.
12.	Fundamental solutions to the Laplace operator, the Cauchy-Riemann operator and the Helmholtz operator.
13.	Cauchy problems.
14.	Retake for the signature/types of exam questions.

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	24 points from the total sum of 80 points obtainable for the two tests.

Assessment schedule

Education week	Topic
8	First-order initial value problems. Canonical forms of the second-order equations and value problems corresponding to them. Basic concepts from topology. Fundamental functions, distributions, generalized derivatives.
13	Operations with distributions, fundamental solutions.
14	Retake.

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	Retake of the signature on week 14 and on the 2nd week of the examination period.

Type of the exam (to be filled out only for subjects with exams)
Written exam.

Calculation of the exam mark (to be filled only for subjects with exams)
According to the scores reached at the written exam.
Final grade calculation methods:
34-40 pts. excellent (5), 28-33 pts. good (4), 22-27 pts. satisfactory (3), 16-21 pts. pass (2), 0-15 pts. fail (1).

References	
Obligatory:	
Recommended:	V.S. Vladimirov: Equations of Mathematical Physics, Mir/ Moscow, 1971 and M. Dekker/New York, 1971. V.I. Arnold: Lectures on Partial Differential Equations, Springer, 2004.
Other references:	

Biomatics and Applied Artificial Intelligence Institute			Semester 4. of the curriculum 2024-25-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Cryptography and quantum cryptography	NBXCQ1EMNF	5	full-time	2	0	2
Responsible person for the subject: Prof. Dr. KOZLOVSZKY Miklós			Classification: professor			
Subject lecturer(s):						
Prerequisites:	NMXAS1EMNF	Algebra and number theory				
Way of the assessment:	exam					
Course description						
Goal:						
Course description:						

Lecture schedule	
Education week	Topic
1.	
2.	
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10.	
11.	
12.	
13.	
14.	
Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	
Assessment schedule	
Education week	Topic
Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)	
Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	
Type of the exam (to be filled out only for subjects with exams)	

Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
References	
Obligatory:	
Recommended:	
Other references:	

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<table>
<tr><td colspan="3">Institute of Applied Mathematics</td><td colspan="4">Semester 4. of the curriculum
2024-25-2</td></tr>
<tr><td rowspan="2">Name of the subject:</td><td rowspan="2">Code of the subject:</td><td rowspan="2">Credits:</td><td colspan="4">Weekly hours:</td></tr>
<tr><td></td><td>lec</td><td>sem</td><td>lab</td></tr>
<tr><td>Information and coding theory</td><td>NMXIK 1EMNF</td><td>4</td><td>full-time</td><td>3</td><td>0</td><td>0</td></tr>
<tr><td colspan="3">Responsible person for the subject: Prof. Dr. TAKÁCS Márta</td><td colspan="4">Classification: professor</td></tr>
<tr><td colspan="7">Subject lecturer(s):</td></tr>
<tr><td>Prerequisites:</td><td>NMXL A1EMN F</td><td colspan="5">Linear algebra</td></tr>
<tr><td>Way of the assessment:</td><td>exam</td><td></td><td colspan="4"></td></tr>
</table>

Course description	
Goal:	The purpose of this course is to provide a summary of the mathematical foundations of information and code theory and to introduce students to the general rules of code theory, compression and cryptography. During the course, students will have a basic understanding of mathematical coding techniques and will gain proficiency in security issues
Course description:	The basic principle of information theory. Information and entropy, schema of communication channel. Variable length source code - prefix code, Huffman code. Conditional entropy and mutual information measure. Channel capacity. Bug fix coding. Finite vector spaces and their relationship to coding. Data compression algorithms. Cryptographic Methods - Summaries.

Lecture schedule

Education week	Topic
1.	Basic concepts of information theory
2.	Information and entropy, Schema of Telecommunication Channel
3.	Variable length source code - prefix code, Huffman code
4.	Conditional entropy and mutual information
5.	Channel Capacity. The basic principle of information theory
6.	1st mid-term exam (online test, if we will have online work schedule)
7.	Error correction coding
8.	Finite vector spaces
9.	Linear Codes (Hamming, Extended and Abbreviated Codes)
10.	Data Compression. Run length compression, LZV
11.	Cryptography, history and algorithms used
12.	2nd mid-term exam (online test, if we will have online work schedule)
13.	Presentation of individual projects
14.	Presentation of individual projects

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	The student may only receive the signature if: - During the semester he / she wrote both midterm exams (maximum score 25 points / midterm exam). Replacement of those exams is possible at a pre-arranged time, in the 14th week of the semester.

	- Prepare an essay related to a new published coding or compression algorithm, submit it in the written form to the Moodle system (4-6 pages). The project should be presented as a presentation at the 13/14th week (online and using ppt or other presentation platform – 8-10 slides) (maximum score 15 points). -The student should prepare / develop homework during the semester, which can be counted towards the end-of-year grade (uploaded it on the Moodle system, maximum score 35 points). In order to complete the signature, the student must have achieved at least 30% of the prerequisites each.

Assessment schedule

Education week	Topic
every week	Consultation time, arranged in advance by email, and on Monday, between 18.00-19.00 on the consultation platform of the Ms Teams system, and in person on Wednesday, 18.30-19.30. during the semester class period.
6th and 12th week	midterm exams
14th week	replacements

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	In the 14th week, there will be an opportunity to replace the midterm exams and to submit missed homework and project. In the absence of the unsuccessful midterm exams and unsuccessful prepared projects, it will be possible to replace them for the signature once within the first 10 days of the exam period, at a predetermined time. The person entitled to a signature replacement is the person who has written his midterm exams or their replacements, has homework and a project, but did not achieve the 30% requirement. Those who did not present at the midterm exams or their regular replacements, did not submit homework and projects, and were absent from more than half of the classes without proof, are not entitled to the signature replacement.

Type of the exam (to be filled out only for subjects with exams)

Written and oral presentation, homeworks, individual project

Calculation of the exam mark (to be filled only for subjects with exams)

Final grade calculation methods

Achieved result	Grade
89%-100%	excellent (5)
76%-88<%	good (4)
63%-75<%	satisfactory (3)
51%-62<%	pass (2)
0%-50<%	fail (1)

Final grade calculation methods:
The final grade is calculated as follows: Midterm exams: 2*25 points, individual project - at best 15 points, uploaded homework at best 35 points. A minimum of 30% must be achieved in each part Final exam (if the offered grade based on the cumulative result during the semester activity is not acceptable for the student or the cumulative points are below 50 points): oral/written answer from the theoretical background. (at best 50 points, 50% of the whole result).

References	
Obligatory:	Gareth Jones, Mary Jones: Information and Coding Theory, Springer (2002), ISBN-13: 978-1852336226
Recommended:	Stefan Moser, Po Ming-Chen, Coding and Information Theory, Cambridge Univ. Press (2012), ISBN-13: 978-1107684577
Other references:	notes and presentations prepared by the lecturer, uploaded to the actual Moodle page

Software Engineering Institute			Semester 3. of the curriculum 2024-25-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Image processing and computer graphics	NSXSK1EMNF	5	full-time	2	0	2
Responsible person for the subject: Dr. VÁMOSSY Zoltán			Classification: associate professor			
Subject lecturer(s):						
Prerequisites:	NMXLA1EMNF	Linear algebra				
Way of the assessment:	mid-term grade					

Course description

Goal:	
Course description:	

Lecture schedule

Education week	Topic
1.	Homogeneous coordinates and 3D transformations. Modeling objects.
2.	Camera models, orthographic and perspective projection. Objects in 3D projections.
3.	The imaging basics. Gray scale and color images features: resolution, histogram, etc.
4.	Typical image noises, distortions. Image enhancements, image filtering. Histogram and modification in compensation.
5.	Methods of edge detection, edge enhancement, smoothing. Line and curve detection, Hough transform.
6.	Morphological operations
7.	Frequency domain methods, FFT, DFT, filtering.
8.	Image segmentation. Edge and region-based methods
9.	Detecting corner points (Harris, KLT), analyzing image regions. Invariant features, edges, texture.
10.	Camera calibration. Motion detection, object tracking. Optical flow models and calculations.
11.	SSD algorithms. Stereo methods, epipolar geometry.
12.	Model-based image processing: active contour methods, splines, ASM, AAM.
13.	Outlook for parallelization opportunities. Midterm test.
14.	Retake

Mid-term requirements

Conditions for obtaining a mid-term grade/signature	Passing at least 51% of the midterm test Completion of the project work

Assessment schedule

Education week	Topic
13	Mideterm test
14	Replacement occasion of the midterm test

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	
Type of the exam (to be filled out only for subjects with exams)	
Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
0% - 50%: fail (1) 51% - 62%: pass (2) 63% - 75%: satisfactory (3) 76% - 88%: good (4) 89% - 100%: excellent (5)	
References	
Obligatory:	**R. Szeliski: Computer Vision Algorithms and Applications, Springer, 2011** **Gonzales, Woods: Digital Image Processing, 3rd edition. Prentice Hall, 2008**
Recommended:	
Other references:	

			Semester 1. of the curriculum 2023-24-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Physical education 1	GTTTS1EMNF	1	full-time	0	1	0
Responsible person for the subject:			Classification:			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	mid-term grade					

Course description

Goal:	
Course description:	

Lecture schedule

Education week	Topic
1.	
2.	
3.	
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Mid-term requirements

Conditions for obtaining a mid-term grade/signature	

Assessment schedule

Education week	Topic

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement

Type of the replacement of written test/mid-term grade/signature	

Type of the exam (to be filled out only for subjects with exams)

<table>
<tr><th colspan="2">Calculation of the exam mark (to be filled only for subjects with exams)</th></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="2">Final grade calculation methods:</td></tr>
<tr><td colspan="2"></td></tr>
<tr><th colspan="2">References</th></tr>
<tr><td>Obligatory:</td><td></td></tr>
<tr><td>Recommended:</td><td></td></tr>
<tr><td>Other references:</td><td></td></tr>
</table>

			Semester 2. of the curriculum 2023-24-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Physical education 2	GTTTS2EMNF	1	full-time	0	1	0
Responsible person for the subject:			Classification:			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	mid-term grade					

Course description	
Goal:	
Course description:	

Lecture schedule	
Education week	Topic
1.	
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Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	

Assessment schedule	
Education week	Topic

Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)

Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	

Type of the exam (to be filled out only for subjects with exams)

Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
References	
Obligatory:	
Recommended:	
Other references:	

Dean's Office			Semester 3. of the curriculum 2024-25-1			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Thesis work I.	NDDDM1EMNF	10	full-time	0	0	0
Responsible person for the subject: Prof. Dr. KRISTÁLY Alexandru			Classification: professor			
Subject lecturer(s):						
Prerequisites:						
Way of the assessment:	signature					

Course description	
Goal:	
Course description:	

Lecture schedule	
Education week	Topic
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Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	
Assessment schedule	
Education week	Topic
Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)	
Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	
Type of the exam (to be filled out only for subjects with exams)	

Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
References	
Obligatory:	
Recommended:	
Other references:	

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Dean's Office			Semester 4. of the curriculum 2024-25-2			
Name of the subject:	Code of the subject:	Credits:	Weekly hours:			
				lec	sem	lab
Thesis work II.	NDDDM2EMNF	10	full-time	0	0	0
Responsible person for the subject: Prof. Dr. KRISTÁLY Alexandru			Classification: professor			
Subject lecturer(s):						
Prerequisites:	NDDDM1EMNF	Thesis work I.				
Way of the assessment:	signature					

Course description	
Goal:	
Course description:	

Lecture schedule	
Education week	Topic
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14.	
Mid-term requirements	
Conditions for obtaining a mid-term grade/signature	
Assessment schedule	
Education week	Topic
Method used to calculate the *mid-term grade* (to be filled out only for subjects with mid-term grades)	
Type of the replacement	
Type of the replacement of written test/mid-term grade/signature	
Type of the exam (to be filled out only for subjects with exams)	

Calculation of the exam mark (to be filled only for subjects with exams)	
Final grade calculation methods:	
References	
Obligatory:	
Recommended:	
Other references:	