

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Approximation Theory		
Lecturer (for lectures)		Džunić S. Jovana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Mastery of advanced techniques in the numerical analysis of polynomials and rational functions, as well as their applications. The course enables students to critically analyze existing numerical methods, assess their efficiency, stability, and limitations, and effectively employ modern software tools for solving complex numerical problems. A key objective of the course is the development of competencies required for independent scientific research, including the critical analysis of contemporary scientific literature, formulation of research problems, and development or refinement of numerical algorithms. Special attention is given to current research directions and open problems in the numerical analysis of polynomials and rational approximation.			
Course outcomes	Upon completion of the course, the student is able to critically analyze and compare contemporary numerical methods based on polynomial and rational approximations, independently develop and refine numerical algorithms for solving complex scientific and engineering problems, and assess their efficiency, stability, and applicability. The student is capable of independently following, analyzing, and evaluating current scientific literature, formulating research problems, and employing modern software tools in the development and verification of new numerical solutions.			
Course outline				
Theoretical teaching	Polynomials and numerical analysis. Representations of polynomials. Univariate polynomials: the polynomial space, algebraic and analytic properties. Numerical determination of polynomial zeros. Polynomial interpolation and approximation. Spline interpolation and approximation. Applications. Rational functions: interpolation, approximation, and applications. Iteration of rational functions. Padé and Hermite interpolation and approximation. Multivariate polynomials. High-dimensional and sparse polynomial approximations. Numerical factorization of polynomials. Contemporary research directions and open problems in the numerical analysis of polynomials and rational functions.			
Practical teaching (exercises, OFE, study and research work)	The study-research component encompasses the critical analysis of current scientific publications in the field of polynomial and rational approximations, the formulation of a research problem, the selection of appropriate numerical methods, and their theoretical and experimental evaluation. Students conduct numerical experiments, analyze the stability, accuracy, and complexity of algorithms, compare the obtained results with those reported in the literature, and formulate conclusions regarding the potential for further development and improvement of the methods.			
Textbooks/references				
1	H. Stetter, Numerical polynomial algebra, SIAM, 2004			
2	Ben Adcock, Simone Brugiapaglia, Clayton Webster, Sparse Polynomial Approximation of High-Dimensional Functions, SIAM, 2022			
3	N. Trefethen, Approximation theory and approximation practice, SIAM, 2013			
4	Peter Junghanns, Giuseppe Mastroianni, Incoronata Notarangelo, Weighted Polynomial Approximation and Numerical Methods for Integral Equations, Springer, 2021			
5	Selected scientific papers from leading international journals published in the last five years, aligned with the current research topics of the course.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Project-based instruction, seminars, and mentoring.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		40
Colloquia				
Projects	60			



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Numerical Linear Algebra		
Lecturer (for lectures)		Džunić S. Jovana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives	Mastery of advanced techniques in applied linear algebra, error analysis, and perturbation theory, with a particular emphasis on their application to contemporary scientific and engineering problems. Students are trained to critically analyze and evaluate existing numerical methods, as well as to design and implement advanced algorithms. A specific objective of the course is the development of competencies necessary for independent scientific research, including the formulation and analysis of research problems, the critical interpretation of results, and the use of modern software tools for numerical computation. Students are also trained in the principles of scientific communication, including the writing and presentation of scientific results in a LaTeX environment, the use of collaborative platforms such as Overleaf, and an understanding of the structure and standards of scientific writing.			
Course outcomes	Upon completing the course, the student is able to independently design, analyze, and improve efficient numerical algorithms in the field of applied and numerical linear algebra. The student is capable of critically assessing the limitations, stability, and efficiency of existing methods and numerical software, as well as comparing them within the context of specific applications. The student is equipped to independently follow, critically analyze, and synthesize results from contemporary scientific literature in numerical linear algebra, and to apply these results in the formulation and solution of research problems.			
Course outline				
Theoretical teaching	Error theory, vector and matrix norms, perturbation analysis, conditioning, and algorithmic stability. The course covers matrix transformations (QR, SVD, Schur) and their applications in dimensionality reduction, least-squares problems, and low-rank approximations. Methods for real-time solution updates and incremental techniques in numerical linear algebra, such as matrix sketching and stochastic methods for dimension reduction with controlled error, are also addressed. Attention is given to fault-tolerant algorithms relevant for use in high-performance computing environments.			
Practical teaching (exercises, OFE, study and research work)	The study-research component encompasses the critical analysis of current scientific publications in the field of numerical linear algebra, the formulation of a research problem, the selection of appropriate numerical methods, and their theoretical and experimental evaluation. Students conduct numerical experiments, analyze the stability, accuracy, and complexity of algorithms, compare the obtained results with those reported in the literature, and formulate conclusions regarding the potential for further development and improvement of the methods.			
Textbooks/references				
	1	C. Meyer, Matrix analysis and applied linear algebra, SIAM, 2000		
	2	A. Bjork, Numerical methods in Matrix computations, Springer, 2015		
	3	N. Higham, Accuracy and stability of numerical algorithms, SIAM, 2002		
	4	Selected scientific papers from leading international journals published in the last five years, with particular emphasis on randomized numerical linear algebra, large-scale computations, and fault-tolerant algorithms.		
	5	Martinsson, Tropp, Randomized numerical linear algebra: Foundations and algorithms, Acta Numerica (2020), pp. 403–572		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Project-based instruction, seminars, and mentoring.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	40
Colloquia				
Projects		60		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Statististics		
Lecturer (for lectures)		Milošević M. Dušan, Džunić S. Jovana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering basic knowledge of statistics and working in the SPSS software package.			
Course outcomes	Complete independence of the student in conducting empirical research, advanced data analysis, and decision-making based on statistical models using the SPSS software.			
Course outline				
Theoretical teaching	Statistical methodology. Descriptive analysis. Arranging and displazing data. Descriptive measures. Measures of central tendency and dispersion. Distributions of discrete and continuous random variables. Sample and sample statistics. Statistical testing methods. Testing statistical hypotheses. Student's T-test. Analysis of variance. Pearson's chi-squared test. Simple linear regression and correlation. Multiple regression and correlation analysis. Factor analysis. Taxonomic analysis. Discrimination analysis. Non-parametric methods. Index numbers. Time series analysis. Working in the SPSS software package.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	S. J. Howard, Experimental Design and Analysis,Online at: http://www.stat.cmu.edu/hse/tman/309/Book/Book.pdf , 2018.			
2	A. Abebe, J. Daniels, J. W. McKean, J. A. Kapenga, Statistics and Data Analysis, Statistical Computation Lab (SCL) Western Michigan University, Kalamazoo, MI, 2001.			
3	J. Pallant, SPSS Survival Manual, sixth edition, Open University Press, 2016.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, computer exercises, consultations, preparation of a seminar paper.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures		10	Written exam	
Exercises			Oral exam	30
Colloquia		30		
Projects		30		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Numerical Mathematics		
Lecturer (for lectures)		Marjanović M. Zvezdan, Rančić Z. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering theoretical and practical knowledge in some areas of numerical mathematics (error propagation and ill-conditioned systems, iterative processes, solving operator equations and their concretization, quadrature processes, approximate solving of ordinary and partial differential equations) using the Mathematica software package.			
Course outcomes	The student's ability to independently monitor and apply the results of contemporary scientific literature in the field of numerical mathematics. The ability to formulate a mathematical model for practical or research problems, select a method for its solution and apply the selected method. The ability to implement mathematical procedures in advanced software packages and analyze the sources and impact of errors that arise during the implementation of the selected method.			
Course outline				
Theoretical teaching	Arithmetic of finite length and numerical processes. General theory of iterative processes. Application to operator equations. Nonlinear equations and systems of nonlinear equations. Quadrature processes and convergence. Cauchy problems and contour problems for ordinary differential equations. Grid method for partial differential equations. Symbolic computations and algorithms. Implementation of algorithms using the Mathematica package.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Richard L. Burden, J. Douglas Faires, Numerical Analysis, Boston, MA : Brooks/Cole, Cengage Learning, 2015.			
2	J.F. Epperson, An Introduction to Numerical Methods and Analysis: Solutions Manual to Accompany, John Wiley & Sons, Inc., 2021.			
3	Randall J. LeVeque, Finite Difference Methods for Ordinary and Partial Differential Equations, SIAM, 2007.			
4	Ake Bjorck, Germund Dahlquist, Numerical Methods in Scientific Computing, Volume I, SIAM, 2008.			
5	K. Atkinson, An Introduction to Numerical Analysis, John Wiley & Sons, 1989.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Computer exercises. Consultations. Project.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Discrete structures and combinatorics		
Lecturer (for lectures)		Matejić M. Marjan, Džunić S. Jovana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Acquiring scientific, theoretical and practical knowledge of enumerative combinatorics, algebraic combinatorics and spectral graph theory.			
Course outcomes	Students should be qualified for further independent scientific and research work in solving various combinatorial problems.			
Course outline				
Theoretical teaching	Special number sequences. Stirling numbers. Bell numbers. Catalan numbers. Euler numbers. Bernoulli numbers. Applications in combinatorial mathematics. Extremal problems. Combinatorial block schemes. Special matrices: binary, Hadamard, stochastic, permutation matrices. Combinatorial distribution and counting problems. Spectral matrices and graph theory. Graph invariants. Energy of matrices and graphs. Directed graphs. Mapping of directed coordinated graphs on plane and line.			
Practical teaching (exercises, OFE, study and research work)	Individual research study.			
Textbooks/references				
1	James A. Anderson, Discrete Mathematics with Combinatorics, Second Edition, Prentice Hall, 2003.			
2	F. R. K. Chung, Spectral graph theory, Providence, 1991.			
3	I. Gutman, B. Furtula, K. Ch. Das, E. Milovanović, I. Milovanović, Bounds in chemical graph theory - Mainstreams, MCM, Kragujevac, 2017.			
4	I. Gutman, X. Li (eds.), Energies of graphs - Theory and applications, MCM, Kragujevac, 2016.			
5	Relevant scientific papers.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consultations, disscussion, individual research.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Special functions		
Lecturer (for lectures)		Marinković D. Slađana, Rančić Z. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to the mathematical apparatus of special functions and its application in professional and scientific research in mathematical or engineering disciplines.			
Course outcomes	Good theoretical knowledge of various classes of special functions and ability to apply them in research in mathematics and engineering. Ability of the student to recognize and use methods of functional analysis in orthogonality theory, in standard and fractional calculus. Ability to critically monitor contemporary literature as a prerequisite for independent research work.			
Course outline				
Theoretical teaching	Hypergeometric functions: definition, recurrence and transformation formulas, differential equation. Functions defined by integrals: Gamma function, Beta function, error function. Bessel functions. Orthogonality in Hilbert space. Orthogonal polynomials: zeros, differential equation, three-term recurrence relation, generating function, hypergeometric representation. Construction of orthogonal polynomials. Classical orthogonal polynomials. Orthogonal polynomials with non-classical weights. Elements of fractional calculus. Fractional integral. Fractional derivative of Riemann-Liouville and Caput type. Mittag-Leffler function.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	G.E. Andrews, R. Askey, R. Roy, Special Functions, Encyclopedia of Mathematics and its Applications, Cambridge University Press, Cambridge, 1999.			
2	Mourad E. H. Ismail, Classical and Quantum Orthogonal Polynomials in One Variable, Cambridge University Press, 2013.			
3	I. Podlubni, Fractional Differential Equations, volume 198 of Mathematics in Science and engineering, Academic Press, San Diego, 1999.			
4	Ch. Li, F. Zeng, Numerical Methods for Fractional Calculus, Taylor & Francis Group, 2015.			
5	Relevant scientific articles.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, projects, consultations, mentoring work.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Mathematical Methods of Optimization		
Lecturer (for lectures)		Marinković D. Slađana, Rančić Z. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering mathematical knowledge from optimization theory and application of various optimization methods. Training in mathematical modeling of real problems from practice or obtained through scientific research, as well as their solution.			
Course outcomes	Students' competence to identify optimization problems in practice or scientific research, form mathematical models, select appropriate methods for their solution and apply the methods. Ability to critically evaluate the efficiency, stability and complexity of optimization methods. Ability to critically monitor contemporary literature as a prerequisite for independent research work.			
Course outline				
Theoretical teaching	Elements of convex analysis. Convex sets and convex functions. Subgradients and generalizations of convexity. Optimality and regularity conditions. Lagrangian function and duality. Linear programming and simplex method. Nonlinear programming. Quadratic programming. Algorithms and convergence. Unconstrained optimization. Constrained optimization. Interior point methods. Multiobjective optimization. Statistical-stochastic methods. Elements of calculus of variations. Variational methods.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	S. Boyd, L. Vandenberghe, Convex optimization, Cambrige University Press, 2009.			
2	M.J. Kochenderfer, T.A. Wheeler, Algorithms for Optimization, second edition, The MIT Press, 2025.			
3	X.S. Yang, Introduction to Mathematical Optimization, Cambridge International Science Publishing, 2008.			
4	Mark Kot, A First Course in the Calculus of Variations, American Mathematical Society, Providence, Rhode Island, 2014.			
5	L. Grippo, M. Sciandrone, Introduction to Methods for Nonlinear Optimization, Springer, UNITEXT 152, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, projects, consultations, mentoring work.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Analysis of Numerical Algorithms		
Lecturer (for lectures)		Marjanović M. Zvezdan, Rančić Z. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Acquiring knowledge in numerical mathematics and training for its application in scientific research and professional work. Introduction to various numerical algorithms and their applications.			
Course outcomes	The student's ability to formulate a mathematical model for a practical or research problem, make a choice of a method for its solution and apply the chosen method. The student's ability to follow contemporary literature, as well as to critically analyze the accuracy and reliability of results obtained through their own research. The ability to analyze the convergence and stability of numerical algorithms, to compare the efficiency of different algorithms from the aspect of accuracy, robustness and error propagation. The ability to improve existing numerical algorithms for solving mathematical problems and, using software tools, carry out their implementation and experimental verification.			
Course outline				
Theoretical teaching	Problems of linear algebra. Direct and iterative methods for solving systems of linear equations, matrix inversion and finding eigenvalues of matrices. Ill-conditioned systems. Nonlinear equations and systems. Newton's and other methods. Newton--Kantorovich method. Algebraic equations. Bernoulli's method. Simultaneous methods. Gauss--Seidel approach. Approximation of functions. Interpolation. Best approximation problem. Differentiation and integration. Newton-Cotes and Gaussian quadrature. Acceleration methods: convergence of sequences and series, matrix multiplication. Aitken method. Euler--Abel transform. Fast Fourier transform (FFT).			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Richard L. Burden, J. Douglas Faires, Numerical Analysis, Boston, MA : Brooks/Cole, Cengage Learning, 2015.			
2	Ake Bjorck, Germund Dahlquist, Numerical Methods in Scientific Computing, Volume II, SIAM, 2008.			
3	Wendland H., Numerical Linear Algebra: An Introduction. Cambridge University Press; 2017.			
4	Cleve Moler, Numerical Computing with MATLAB, The MathWorks, 2004.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, presentations, seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Spectral graph theory		
Lecturer (for lectures)		Matejić M. Marjan, Džunić S. Jovana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The main aim of the course is the acquisition of knowledge and techniques of the spectral graph theory.			
Course outcomes	The student has acquired theoretical knowledge necessary for understanding the problems related to the spectral graph theory and its application in other fields of mathematics, as well as in natural and technical sciences. The student mastered the skills and methods of research in this field.			
Course outline				
Theoretical teaching	Topological indices of a graph based on the degrees of vertices and edges (Zagreb indices, Randić indices, geometric-arithmetic topological index, ABC topological index, ISI, SDD). Basic characteristics of topological indices, bounds, values on concrete graphs. Matrices associated with the graph (adjacency matrix, adjacency matrix by edges, incident matrix, Laplacian matrix, normalized Laplacian matrix, Randic matrix, signless Laplacian matrix). Graph spectrums and basic properties. Energy of matrices and graphs. Kirchhoff indices. Regular graphs. Measures of irregularity of graphs.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	D. M. Cvetković, M. Doob, H. Sachs, Spectra of graphs, Johann Ambrosius Barth Verlag, Heidelberg - Leipzig, 1995.			
2	F. R. K. Chung, Spectral graph theory, American Mathematical Society, 1997.			
3	A. E. Brouwer, W. H. Haemers, Spectra of graphs, Springer, 2012.			
4	Relevant scientific papers.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, student seminars, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Highly Efficient Iterative Methods		
Lecturer (for lectures)		Rančić Z. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Students are trained to contribute to the development of new iterative methods and their application.			
Course outcomes	Students are familiar with the construction elements and the analysis of the convergence of iterative methods for solving some classes of nonlinear equations and the linear equations system. They are trained to apply acquired knowledge through self-study and possibly writing scientific paper in this topic.			
Course outline				
Theoretical teaching	Basic characteristics of iterative methods. Convergence analysis, order of convergence, R-order of convergence. Initial values problem and stability of methods. High precision iterative methods for determining the zeroes of the analytic function and the zeroes of polynomial. Iterative methods for determining the solution of the linear equations system . Visualisation of iterative process. Application of mathematical software tools in realization of the mentioned methods.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Miodrag Petković, Djordje Herceg, Snežana Ilić, Point Estimation Theory and its Applications, Institute of Mathematics, Novi Sad 1997.			
2	Miodrag Petković, Iterative Methods for Simultaneous Inclusion of Polynomial Zeros, Springer-Verlag-Berlin-Heidelberg-New York,1989, Reprinted 2008.			
3	Lidija Rančić, Svetozar Rančić, Basins of attractions of new iterative methods for finding simple zeros, FACTA UNIVERSITATIS (NIŠ) Ser. Math. Inform. Vol. 39, No 5 (2024), 843–849			
4	I.Petković, L. Rančić, Computational Geometry as a Tool for Studying Root-Finding Methods, Filomat 33:4 (2019), 1019–1027			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, tutorials			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Simulation of Industrial Systems		
Lecturer (for lectures)		Milojković T. Marko, Perić Lj. Staniša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The aim of this course is to equip students with advanced theoretical knowledge and practical skills in the simulation of complex industrial systems. The emphasis is on the development, validation and application of simulation techniques for analyzing system behavior, optimizing performance and supporting decision-making in industrial environments.			
Course outcomes	Knowledge of the mathematical foundations of quality simulation and the design of adequate simulation models in order to solve practical problems in various branches of industry. Knowledge of the operation of appropriate software for system simulation as well as modern trends in the simulation of industrial systems.			
Course outline				
Theoretical teaching	Concept and methods of simulation. Design of simulation models. Simulation tools. Mathematical basis of digital simulation. Numerical methods implemented in simulation tools. Simulation of systems with distributed parameters. Simulation of systems with discontinuities. Simulation errors and methods for overcoming them. Application of simulation in the identification, design and optimization of automatic control systems. Real-time simulation, hardware and software aspects, numerical integration algorithms. Simulation of industrial systems. Simulation of complex systems. Modern trends in the simulation of industrial systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	P. J. Thomas, "Simulation of Industrial Processes for Control Engineers", Butterworth-Heinemann, 1999.			
2	Fang Fang, Qingwei Meng, "Handbook of Simulation of Industrial Processes for Control Engineers", AURIS REFERENCE LIMITED, 2015.			
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	The forms of teaching (classical - lectures or mentoring - consultations) are adjusted to the number of students. With the help of scientific journals and other literature, the student deepens the material from the lectures, and through consultations and study research work with the teacher, the student is trained to independently write a scientific paper. The student is required to independently complete the project.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Mathematical Models in Industry		
Lecturer (for lectures)		Antić S. Dragan, Milojković T. Marko		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The aim of this course is to provide students with advanced knowledge and practical skills in the development, analysis and application of mathematical models to solve complex industrial problems. The emphasis is on the integration of mathematical theory with real industrial processes in various sectors.			
Course outcomes	Developing students' ability to design and critically evaluate mathematical models used in industry, with a focus on predictive modeling, optimization, and system simulation. Students will engage with case studies and real-world industrial data to bridge the gap between theoretical methods and practical applications.			
Course outline				
Theoretical teaching	The concept of a dynamic system model. Model classification. Abstract models. Principles of mathematical model design. Types of mathematical models. Examples of mathematical models. Design of mathematical models of technical systems (mechanical, hydraulic, thermal, chemical, technological). Simplification of mathematical models. Model validation and verification techniques. Mathematical modeling of disturbances. Modeling of industrial systems. Modeling of complex systems. Modern trends in modeling of industrial systems. Modeling of systems using orthogonal functions. Use of genetic algorithms, fuzzy logic and neural networks in the design of mathematical models in industry. Commercial software for modeling industrial systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	C. Close, D. Frederick, J. Newell, "Modeling and Analysis of Dynamic Systems", John Wiley & Sons, 2002.			
2	Payam Zarafshan, "Modeling and Simulation of Dynamical Systems", Academic Press, 2024.			
3	Robert L. Woods, Kent L. Lawrence, "Modeling and Simulation of Dynamical Systems", Pearson, 1997.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	The forms of teaching (classical - lectures or mentoring - consultations) are adjusted to the number of students. With the help of scientific journals and other literature, the student deepens the material from the lectures, and through consultations and study research work with the teacher, the student is trained to independently write a scientific paper. The student is required to independently complete the project.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program			Electrical Engineering and Computer Science	
Type and level of studies			Doctoral Studies	
The name of the course			Mathematical Foundations of Statistical Learning and Applications	
Lecturer (for lectures)			Perić H. Zoran, Milošević M. Dušan, Nikolić R. Jelena	
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites				
Course objectives		Introduction to the mathematical basics of statistics and statistical learning. Enabling students to apply the acquired knowledge on the concrete tasks.		
Course outcomes		Acquired fundamentals of statistical learning and ability to practically use the acquired knowledge in the signal and data processing.		
Course outline				
Theoretical teaching		Point estimates, confidence intervals. Nonparametric methods for distribution hypothesis testing. Maximal likelihood method. Linear regression, dependence between two random variables, regression line, dependence between random and control variable. Nonlinear regression, piecewise linear regression, logistic regression. Time series analysis, linear and nonlinear prediction. AR processes, MA processes and ARMA processes. Training algorithms based on statistical learning. Algorithms		
Practical teaching (exercises, OFE, study and research work)		Lectures. Consultations. Work on project.		
Textbooks/references				
1	G. James, D. Witten, T. Hastie, R. Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer, 2017.			
2	T. Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009.			
3	V. N. Vapnik, Statistical Learning Theory, Wiley-Interscience, 1998.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Lectures. Consultations. Work on project.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Systems		
Lecturer (for lectures)		Đošić M. Sandra, Jovanović D. Milica		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The objective of the course is to expand and build upon the fundamental knowledge acquired in digital electronics and digital system design, and to guide students toward adopting new design techniques and methodologies necessary for the design, analysis, and implementation of complex high-performance digital systems.			
Course outcomes	Students will gain the ability to, through the application of modern design methods and techniques supported by appropriate software tools: a) design, analyze, and implement digital systems of varying levels of complexity; b) explore alternative solutions to identify the optimal trade-off between hardware complexity, performance, and power consumption, (c) critically analyze existing scientific results and methodologies, and (d) develop new approaches, techniques, and solutions through independent original scientific research.			
Course outline				
Theoretical teaching	Fundamental characteristics of modern digital systems. Advanced technologies in the implementation of logic, combinational, and sequential digital circuits. Low-voltage and low-power digital systems. Asynchronous digital systems. Methodologies for designing complex digital systems at various levels of abstraction: RTL design and high-level synthesis. Synthesis of the datapath and control unit. Techniques for enhancing digital system performance: pipelined and parallel architectures. Principles of hardware implementation of arithmetic functions and DSP algorithms. Architectures of programmable digital circuits. Fault-tolerant digital systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	D. Gajski, Principles of Digital Design, Prentice-Hall, Inc. Upper Saddle River, NJ, 1997.			
2	N.H E. Weste, D. M. Harris, CMOS VLSI Design - A Circuits and Systems Perspective, 4th Edition, Addison Wesley, 2010			
3	E.C. Ifeachor, B. W. Jervis, Digital Signal Processing: A practical approach, Pearson Education, PHI/ 2002			
4	Ata Elahi, Computer Systems: Digital Design, Fundamentals of Computer Architecture and Assembly Language, Springer Nature, 2022			
5	Digital Systems, course notes and PowerPoint presentations for lectures, problem-solving sessions, and laboratory exercises, available on the course website.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, seminars, assignments, and class discussions. Independent and team work of students in solving research-oriented tasks.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Power Electronics		
Lecturer (for lectures)		Mančić D. Dragan, Jovanović D. Igor		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Expanding and upgrading the fundamental knowledge acquired in the field of power electronics and guidance towards the adoption of new techniques required by concrete and specific applications which are subject of interest to students.			
Course outcomes	Students gain the necessary theoretical and practical knowledge to meet any specific request in development, modeling, performance assessment, optimization, realisation, control, practical application and verification of the various devices of power electronics with medium level of complexity, primarily of the various power electronic converters.			
Course outline				
Theoretical teaching	Types of semiconductor power electronic switches. AC/DC converters. Rectifiers in switching mode of operation. Rectifiers for power factor corrector. Multi-quadrant work. DC/DC converters. DC/AC converters. Soft starters, frequency converters. Converters for medium voltage levels. Methods of control. Direct AC/AC converters. Sizing the components of inverter. Influence of converters on the power grid and electrical consumers. Utilization of special purpose softwares in the operation analysis of inverters.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	N.Mohan, TMUndeland, WPRObbins, "Power electronics: Converters, Applications, and Design", John Wiley & Sons., New York, 2007.			
2	M.H.Rashid, "Power Electronics Handbook", Elsevier Science, 2017.			
3	P.C.Sen, "Principles of Electric Machines and Power Electronics", John Wiley & Sons Inc., New Jersey, 2013.			
4	R.W.Erickson, D.Maksimovic, "Fundamentals of Power Electronics, Third Edition", Springer, 2020.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is held in lectures while simultaneously mentoring students. Individual and team work of students takes place during their practical and scientific and research work on the defined projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Computer Architecture		
Lecturer (for lectures)		Nikolić R. Tatjana, Nikolić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives	The objective of the course is to provide students with a detailed and critical understanding of modern computer architectures, with an emphasis on the design of high-performance systems, energy efficiency, parallel and heterogeneous processing, as well as domain-specific architectures such as those tailored for artificial intelligence and Edge/Cloud infrastructures.			
Course outcomes	The student acquires knowledge and research competencies that enable them to: a) classify, explain, and critically evaluate fundamental and advanced concepts of modern computer architectures; b) analyze and compare architectural techniques employed in next-generation processors and memory systems; c) apply appropriate methods and metrics for the evaluation of computer architecture performance; d) design, model, and evaluate multicore architectures, heterogeneous systems, and specialized hardware components; e) investigate and develop novel approaches for accelerating program execution and improving system energy efficiency; f) critically analyze and interpret results published in contemporary scientific literature; g) independently formulate research problems and propose original architectural solutions based on scientific methodology.			
Course outline				
Theoretical teaching	Overview of advanced computer architectures: pipelined processors, superscalar, VLIW, multicore and multithreaded processor architectures, heterogeneous architectures. Memory system – internal register files, scratch pad memory, cache hierarchy, main memory organization, virtual memory. Memory coherence, synchronization, and consistency. Input-output organization and interfaces. Application-specific processors. High-performance and energy-efficient processors. Architectures for parallel and domain-specific computing (GPU, TPU, NPU, Edge AI). Computer architectures for artificial intelligence and big data. RISC-V modularity and extensions. Programming techniques. Computer system simulators. Performance, power, and silicon area evaluation.			
Practical teaching (exercises, OFE, study and research work)	Research activities include the following: 1) Experimental evaluation and comparative analysis of modern computer architectures using simulation tools. 2) Design and modification of processor architectures within the RISC-V environment. 3) Simulation, statistical processing of results, and their interpretation through comparison with reference architectures and findings reported in the literature. 4) Analysis of the impact of cache memory parameters and coherence protocols on system performance, including the measurement and comparison of metrics such as throughput, latency, resource utilization, and energy efficiency. 5) Review and critical analysis of contemporary scientific publications, identification of limitations of existing solutions, and formulation of potential directions for their improvement.			
Textbooks/references				
1	John L. Hennessy, David A. Patterson, Christos Kozyrakis, Computer Architecture: A Quantitative Approach, 7th Edition, Morgan Kaufmann, 2025.			
2	David A. Patterson, John L. Hennessy, Computer Organization and Design - RISC-V Edition: The Hardware Software Interface, Morgan Kaufmann, 2020.			
3	Jim Ledin, Modern Computer Architecture and Organization: Learn x86, ARM, and RISC-V architectures and the design of smartphones, PCs, and cloud servers, 2nd Edition, Packt Publishing, 2022.			
4	Thomas Rauber, Gudula Rünger, Parallel Programming: for Multicore and Cluster Systems, Springer, 2023.			
5	Liliana Andrade, Frederic Rousseau (Editors), Multi-Processor System-on-Chip 2: Applications, Wiley-ISTE, 2021.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is conducted through lectures and individual mentoring. Students participate in both independent and team-based work on solving tasks within scientific research projects.			
Grade (maximum number of points 100)				

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Optimization and Design of Analog Circuits		
Lecturer (for lectures)		Andrejević-Stošović V. Miona, Đorđević D. Srđan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Expansion of knowledge acquired in analog electronics, analog integrated circuits and analog integrated circuit design from undergraduate and master's studies. Use of artificial neural networks and machine learning in the optimization and design of analog electronic circuits.			
Course outcomes	Acquiring the necessary conditions for writing a doctoral dissertation in the field of analog electronic circuits. Using software tools to apply the concept of artificial neural networks or machine learning techniques.			
Course outline				
Theoretical teaching	Transistor modeling. Optimization of parameters of basic analog electronics circuits: amplifier stages, operational amplifiers, comparators, reference voltage sources, polarization circuits in CMOS and BiCMOS technology. Transconductance, quarter-quadrant and PWAM analog multipliers. Analog (PLL) and digital (DLL) phase-locked loops. RC, SC and SI filters. Oscillators. Optimization of analog electronic circuit performance (power consumption, speed, noise).			
Practical teaching (exercises, OFE, study and research work)	Acquired theoretical knowledge is extended by acquiring skills in optimizing and designing analog integrated circuits using the professional software package for designing integrated circuits, IC Cadence Design Systems (CDS).			
Textbooks/references				
1	João P. S. Rosa, Daniel J. D. Guerra, Nuno C. G. Horta, Ricardo M. F. Martins, Nuno C. C. Lourenço, Using Artificial Neural Networks for Analog Integrated Circuit Design Automation, First Edition, Springer, 2020, 119 pp., ISBN: 978-3030357429.			
2	Vazgen Melikyan, Machine Learning-based Design and Optimization of High-Speed Circuits, Springer Nature Switzerland, 2023, 338 pp., ISBN: 978-3031507144.			
3	Behzad Razavi, Design of Analog CMOS Integrated Circuits Second Edition, McGraw Hill Education, 2017, 782 pp., ISBN: 978-0-07-252493-2.			
4	T. C. Carusone, D. A. Johns and K. W. Martin, ANALOG INTEGRATED CIRCUIT DESIGN, John Wiley & Sons, Inc., 2012, 794 pp., ISBN: 978-0-470-77010-8.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Project assignments, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Signal Processing		
Lecturer (for lectures)		Nikolić V. Saša, Stančić Z. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Presentation of advanced techniques in digital signal processing. Application of the most modern algorithms for the synthesis of digital filters.			
Course outcomes	Mastering modern approaches for designing and implementing digital filters. Acquiring practical engineering skills and ability to solve practical problems.			
Course outline				
Theoretical teaching	Multiresolution signal analysis (including Wavelet transformation), spectral analysis, real-time filtering, adaptive processing, signal processing in the presence of noise, as well as multidimensional and biomedical signal processing. Special attention is paid to time-frequency techniques, statistical and stochastic models, as well as the impenetation of algorithms in the Matlab (Python) evironment and on hardware platforms (DSP processors or FPGA). Critical analysis and innovative applications of signal processing techniques in different domains - from communications systems and audio technologies until medical diagnostics and intelligent systems.			
Practical teaching (exercises, OFE, study and research work)	Practical implementation of algorithms for design of digital filters. Interpolation. Decimation. Application of filter banks.			
Textbooks/references				
1	J. Lim, A. Oppenheim: Advanced topics in signal processing, Prentice Hall			
2	Y. Hussain, A. Sadik, P. O Shea: Digital Signap Processing, Springer, 2011.			
3	J.G. Proakis, D.G. Manolakis: Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall, 1996			
4	S. Smith: The Scientist and Engineer's Guide to Digital Signal Processing, California Technical Publishin, 1999			
5	Li Tan, Jean Jiang: Digital Signal Processing: Fundamentals, Applications and Deep Learning, Academic Press, 2025			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Presentation on specific topics, seminars, projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	30
Exercises			Oral exam	30
Colloquia				
Projects		40		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electronic Circuits and Systems Design		
Lecturer (for lectures)		Jovanović D. Borisav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Systematization of knowledge related to the design of highly integrated circuits.			
Course outcomes	Gaining competence in the design of highly integrated circuits, from RTL description to implementation on advanced development platforms.			
Course outline				
Theoretical teaching	VLSI technology. Structure of VLSI systems. VLSI architecture design. Circuit synthesis. Design of advanced systems using pre-built IP blocks. Utilization, configuration, and programming of advanced microprocessors embedded in FPGA chips (MicroBlaze/Zynq CPU). Application of advanced features offered by modern FPGA systems, such as AXI buses, DDR memory, SERDES communication links, etc. Data transfer between different digital blocks within FPGAs using AXI buses. Use of embedded logic analyzers and programmable inputs.			
Practical teaching (exercises, OFE, study and research work)	Use of the DDR Memory Interface Generator (MIG) IP core. Writing to and reading from onboard DDR memory chips. Use of the UART IP core for establishing a communication link with a general-purpose computer. Development of basic host PC software to control the designed hardware. Design and implementation of a digital transceiver. Establishing reliable communication between the FPGA board and analog front-end (AFE) transceivers containing high-performance ADCs and DACs capable of operating in the RF GHz frequency range. Communication link based on the JESD204C protocol. Use of JESD204C IP cores. Laboratory exercises utilize modern AMD Xilinx development boards and the AMD Xilinx Vivado/Vitis software development platform.			
Textbooks/references				
1	K.C. Chang, Digital Systems Design with VHDL, An Integrated Approach, IEEE Computer Society, ISBN 0-7695-0023-4, Year 1999			
2	Xiaokun Yang, Integrated Circuit Design: IC Design Flow and Project-Based Learning,CRC Press, Year 2024, ISBN 978-1032030791			
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures with projector presentations, audio-assisted exercises, computer-based laboratory sessions, consultations, and individual student projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures		10	Written exam	
Exercises		10	Oral exam	30
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Simulation and Optimization of Electronic Circuits and Systems		
Lecturer (for lectures)		Milić Lj. Miljana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Acquisition and systematization of knowledge on algorithms for the analysis and optimization of analog circuits, as well as the simulation of digital and mixed-signal circuits. Development of advanced skills and techniques in optimization within the field of machine learning.			
Course outcomes	By the end of the course, students will have developed competencies in modeling electronic components, analyzing and optimizing analog circuits, and simulating digital and mixed-signal circuits, enabling them to create their own software tools. Additionally, students will gain skills in applying and improving optimization techniques within machine learning frameworks.			
Course outline				
Theoretical teaching	Analog Circuit Simulation: Abstraction domains: DC, steady-state periodic, and time domain; Equation formulation concepts for circuit analysis; Simulation algorithms; Frequency domain and s-domain analysis; Simulation of linear and nonlinear, resistive and reactive circuits; Simulation of circuits with distributed parameters; Modeling of electronic components. Digital Circuit Simulation: Simulation algorithms; Signal and operator modeling; Delay modeling. Mixed-Signal Circuit Simulation. Power Supply Current Generation and Methods for Power and Delay Estimation. Circuit Optimization: Optimization methods based on Newton's algorithm; Statistical optimization methods; Concepts of tolerances and yield; Tolerance analysis; Optimization techniques in machine learning.			
Practical teaching (exercises, OFE, study and research work)	As part of the course, students complete a practical project or seminar paper.			
Textbooks/references				
1	Vanco Litovski, Mark Zwoliński: VLSI Circuit Simulation and Optimization, Springer, 1996.			
2	Mark Zwoliński: Digital System Design with VHDL, Prentice Hall, 2000.			
3	Sebastian Raschka, Vahid Mirjalili: Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2, 3rd Edition, Packt, 2015.			
4	Francois Chollet, Matthew Watson : Deep Learning with Python, Third Edition, 2025.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Students complete an individual project or publish a paper in this field.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	30
Colloquia				
Projects		70		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science	
Type and level of studies		Doctoral Studies	
The name of the course		Data Communication and Networking	
Lecturer (for lectures)		Đorđević Lj. Goran, Jovanović D. Milica	
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS	12	Course status (obligatory/elective)	Elective
Prerequisites	None		
Course objectives	Acquire and deepen Knowledge in data transmission and networking, with an emphasis on modern concepts and the development of computer-based systems for efficient and high-speed data transfer across various communication media. Familiarize students with current trends in the development of: wireless communication technologies, ad-hoc networks, mobile computing and sensor networks. Enhance problem-solving abilities in troubleshooting and optimizing distributed embedded networks for performance, reliability, and power efficiency.		
Course outcomes	The learning outcome of this course is the acquisition of advanced theoretical knowledge and research competencies in the field of contemporary data communication and networking systems, including: (a) a critical understanding of the technologies, concepts, principles, and emerging trends in modern data communication systems; (b) the analysis, comparison, and evaluation of different network architectures and their characteristics; and (c) the critical analysis of the operating principles, performance, and application domains of contemporary network protocols. Upon successful completion of the course, students are able to independently formulate research problems, design and analyze computer-based data communication networks, apply appropriate modeling and performance evaluation methodologies, critically assess scientific results and existing solutions reported in the literature, and develop and improve methods, models, and solutions in the field of data communication and networking systems.		
Course outline			
Theoretical teaching	Evolution of Network Architectures and Models: ISO-OSI and TCP/IP models, modern network paradigms (SDN, NFV, cloud-based networking). Introduction to 5G and 6G architectures (key features, use cases). Transmission media and techniques: media characteristics, multiplexing and switching, modulation and coding for wireless systems. Network access and signaling. Local wireless networks. Industrial networks and Industrial IoT. Network Layer: addressing, routing protocols, multicast support, network virtualization and segmentation. Transport layer protocols, congestion control, and QoS. Application layer: client-server and P2P architectures, application protocols, multimedia communication.		
Practical teaching (exercises, OFE, study and research work)	Practical instruction includes the analysis and critical evaluation of scientific and professional literature in the field of contemporary data communication and networking systems. Students independently model, simulate, and analyze various network architectures, protocols, and communication mechanisms using modern software tools and simulation environments. As part of their practical work, students design and conduct experiments for network performance evaluation, analyzing parameters such as bandwidth, latency, packet loss, reliability, and quality of service, as well as the impact of different routing, congestion control, and medium access mechanisms on system performance. Particular attention is devoted to the analysis and evaluation of solutions for mobile, ad hoc, sensor, and IoT networks, as well as the application of security mechanisms in communication systems. Based on the obtained results, students perform comparative analyses with existing solutions reported in the literature, critically interpret the results, and formulate conclusions and recommendations for the improvement of architectures, protocols, and methodologies in the field of data communication and networking systems.		
Textbooks/references			
	1	J. F. Kurose, K. W. Ross, Computer Networking: A Top-Down Approach, 8th Edition, Pearson, 2021	
	2	E. Dahlman, S. Parkvall, J. Sköld, 5G NR: The Next Generation Wireless Access Technology, 2nd Edition, Academic Press, 2020.	
	3	W. Stallings, Data and Computer Communications, 11th Edition, Pearson, 2022.	
	4	T. D. Nadeau, K. Gray, SDN: Software Defined Networks, 2nd Edition, O'Reilly Media, 2023.	
	5	M. Liyanage, I. Ahmad, A. B. Abro (Eds.), 6G and Beyond: The Future of Wireless Communications Systems, Wiley-IEEE Press, 2024.	
Number of classes of active education per week during semester/trimester/year			
Lectures	Exercises	OFE	Study and research work
			Other classes

3	/	/	0	0
Teaching methods	Lectures, seminars, assignments, and class discussions. Independent and team work of students in solving research-oriented tasks.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam	Points	
Activity during lectures		Written exam		
Exercises		Oral exam	50	
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Approximation Methods		
Lecturer (for lectures)		Stančić Z. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Extension and enhancement of fundamental knowledge acquired in the field of analog and digital signal processing, with the aim of adopting new approximation techniques. Development of competencies for designing filter functions that are optimal according to a given criterion.			
Course outcomes	Students acquire the necessary level of theoretical and practical knowledge to meet any specific requirements related to the design, modeling, performance evaluation, sensitivity analysis, and optimization of filter functions, as well as the optimization of implementation structures of analog and digital filter systems.			
Course outline				
Theoretical teaching	Approximation problems. Methods for amplitude response approximation. Maximally flat response. Mini-max amplitude response. Least squares approximation. Transition characteristics. Methods for phase response approximation. Maximally flat phase and group delay characteristics. Mini-max phase and group delay characteristics. Interpolation techniques in phase approximation. Simultaneous approximation of amplitude and phase. Phase and amplitude correctors. Other phase approximation methods. Time-domain approximation methods. Mini-max approximation. Approximation by minimizing the mean square error. Interpolation technique. Linear programming and digital filter design.			
Practical teaching (exercises, OFE, study and research work)	Methods for approximating the characteristics of digital filters in the frequency domain. Mini-max approximation. Approximation by minimizing the mean square error. Interpolation technique. Other approximation methods. Application of approximation techniques in the design of phase correctors, Hilbert transformers, digital differentiators and integrators, DC removers of first and higher order.			
Textbooks/references				
1	Jon G. Proakis, Dimitris Manolakis, Digital Signal Processing, Pearson, 2007.			
2	S. Mitra, Digital signal processing A computer based approach, McGraw-Hill, 2006.			
3	Hans J. Stetter: Numerical polynomial algebra, SIAM, Vienna, Austria, 2004.			
4	Recent scientific papers in the specified field			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures; consultations; excercises; demonstrations in Matlab;			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Artificial Intelligence in Engineering		
Lecturer (for lectures)		Andrejević-Stošović V. Miona		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Application of artificial intelligence algorithms with an emphasis on the concept of artificial neural networks. Training for the independent application of concepts to problems in the electrical engineering profession.			
Course outcomes	Upon completion of the course, students will demonstrate expertise in data preparation and analysis, implement classical machine learning models and deep neural network models using standard software tools. They will also be able to use generative artificial intelligence to improve engineering processes and decision-making.			
Course outline				
Theoretical teaching	The concept of artificial intelligence. Artificial intelligence based on production rules. Artificial neural networks. Natural nervous system. Neuron. Synapse. Neuron model. Architectures of artificial neural networks. Learning. Perceptron. Possibilities, learning algorithms and capacity of perceptron. Multilayer neural networks. Backpropagation algorithm. Recurrent neural networks. Types, learning and application problems. Dynamic learning processes. Genetic algorithms. Implementation of artificial neural networks. VLSI implementation of analog neural networks. Digital implementation of neural networks. Boltzmann machine. Neuro-fuzzy networks and their applications.			
Practical teaching (exercises, OFE, study and research work)	Application in general purpose computers. Neural computers. Specialized ICs that implement artificial neural networks. Application of neural networks in CAD, image and signal processing, in OCR systems. Hardware implementation of artificial neural networks on FPGA.			
Textbooks/references				
1	Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning , MIT Press, 2016.			
2	Sebastian Raschka, Yuxi Liu, Vahid Mirjalili, Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python, Pack Publishing, 2022.			
3	Abhishek Thakur, Approaching Almost Any Machine Learning Problem, Amazon Digital Services, 2020.			
4	Andriy Burkov, Machine Learning Engineering, Amazon Digital Services, 2020.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Project assignments, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		RF Integrated Circuits		
Lecturer (for lectures)		Mirković D. Dejan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to the RF integrated circuits technology, manufacturing, design and verification procedures. Description of the process of measuring and testing of a manufactured circuit. Presentation of the work of an RF designer, in a standard working environment, which involves the use of complex specialized programs for the design of RF circuits.			
Course outcomes	Students should master the theoretical and practical knowledge necessary for the implementation of complex RF projects on a chip.			
Course outline				
Theoretical teaching	BiCMOS technology for RF and analog circuits. Design kit, installation, design rules, most important parameters. Element libraries, schematic symbols, models, layout. Cell libraries. Creating a new cell. Drawing layout and layers. Contacts for RFIC, bonding, chip packaging. On-chip transmission lines, as elements of matching networks and microstrip filters. Electromagnetic layout simulation. Equivalent S (reflection) layout parameters. Verification whether the chip layout matches the schematic (LVS). Verification whether the design rules are respected (DRC). Design simulation. GDSII format. Fabrication process.			
Practical teaching (exercises, OFE, study and research work)	Projects: low-noise amplifier, mixer, oscillator, phase (frequency) locked loop (P(F)LL). For project development, a professional integrated circuit design software package, IC Cadence Design Sysrms (CDS), is available.			
Textbooks/references				
1	Behzad Razavi, RF Microelectronics, Second Edition, Prentice Hall, 2012, 910 pp., ISBN-10: 0-13-713473-8			
2	Lee H. Thomas, The Design of CMOS Radio-Frequency Integrated Circuits, Second Edition, Cambridge University Press, 2004, 797 pp., ISBN: 978-0-521-83539-8			
3	Ali Niknejad, Electromagnetics for High-Speed Analog and Digital Communication Circuits, Cambridge University Press, 2007, 445 pp., ISBN-13: 978-0-521-85350-7			
4	Ali Niknejad, Robert Mayer, Inductors and Transformers for Si RF ICs, KLUWER ACADEMIC PUBLISHERS, 2002, 190 pp., ISBN: 0-792-37986-1			
5	Alan Hastings, The Art of Analog Layout, Second Edition, Prentice Hall, 2000, 648 pp., ISBN-13: 978-0130870612			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consultations, project examples and laboratory exercises (tutorials).			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	30
Colloquia				
Projects		70		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Processing of Audio Signal		
Lecturer (for lectures)		Stančić Z. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Introduction to the methods for designing and implementing analog and digital filters for audio signal processing. Crossover filter design with specified attenuation. Notch filters for compensating the characteristics of audio drivers. Phase analysis and compensation. Digital music signal processing. Introduction to methods for implementing echo and reverberation. Equalizers. Introduction to techniques for modeling musical instruments.		
Course outcomes		Mastering techniques for the design and implementation of analog audio filters. Understanding techniques for digital music signal processing. Offline digital signal processing in MATLAB.		
Course outline				
Theoretical teaching		Design of Analog Filters. Linkwitz-Riley Filter and Phase Analysis. Crossovers up to 24 dB/oct. Characteristics of Loudspeakers/Drivers and Selection of Crossover Frequencies. Compensation of Frequency Response. Design of Compression, Bass-Reflex, and Transmission Line Speaker Enclosures. 2.1 Speaker Enclosures. Normalization. Frequency Transformations. Digital Music Signal Processing. Implementation of Echo. Implementation of Reverberation Using Various Digital Filters. Chorus and Flanging Effects. Notch Filters in Signal Processing. Equalizers for Music Signal Processing.		
Practical teaching (exercises, OFE, study and research work)		Digital Music Signal Processing in MATLAB. Analysis of Filter Characteristics for Signal Processing. Sensitivity of Characteristics and the Impact of the Finite Word Length on the Representation of Transfer Function Coefficients. Filter Banks.		
Textbooks/references				
1		Udo Zolzer: DAFX - Digital audio effects, John Wiley & Sons, Hamburg, Germany, 2011.		
2		Julius O. Smith: Physical audio signal processing, CCRMA, Stanford, https://ccrma.stanford.edu/~jos/pasp/		
3		Julius O. Smith: Introduction to digital filters, CCRMA, Stanford, https://ccrma.stanford.edu/~jos/filters/		
4		Scientific Papers in the Field of Audio Signal Processing		
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures; consultations; excercises; demonstrations in Matlab;			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Circuits and Systems Design		
Lecturer (for lectures)		Milić Lj. Miljana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The goal of the course is for students to acquire advanced theoretical and practical knowledge in the design of complex digital circuits and systems. Special emphasis is placed on modern methodologies, tools, and techniques that enable a high level of optimization and reliability of digital systems.			
Course outcomes	Upon completion of the course, students will be qualified to independently conduct research and develop innovative solutions in the design of integrated digital circuits and systems. They will also be able to apply advanced methods for analysis, verification, and synthesis of digital circuits and systems in both industrial and research environments.			
Course outline				
Theoretical teaching	The theoretical instruction covers advanced concepts in digital circuit design, including formal methods for modeling, verification, and optimization at both the logical and system levels. It also addresses circuit design using modern VLSI technologies, as well as architectures of application-specific digital blocks and systems. Contemporary design flows (EDA tools), methodologies for synthesis and testing, and approaches to designing reliable and energy-efficient digital systems are analyzed.			
Practical teaching (exercises, OFE, study and research work)	The practical part of the course involves research on individual projects where students engage in the design, simulation, and verification of complex digital systems using modern EDA tools and HDL languages.			
Textbooks/references				
1	Vanco Litovski, Mark Zwoliński: VLSI Circuit Simulation and Optimization, Springer, 1996.			
2	Mark Zwoliński: Digital System Design with VHDL, Prentice Hall, 2000.			
3	uman Lata Tripathi, Sobhit Saxena, Sushanta Kumar: Advanced VLSI Design and Testability Issues, 1st Edition, SRC press, 2022.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures and student research work.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	30
Colloquia				
Projects		70		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Embedded System Design		
Lecturer (for lectures)		Nikolić R. Tatjana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The objective of the course is to enable students to conduct research and development of complex embedded systems, with special attention given to next-generation architectures, hardware-software coherence, energy efficiency, high performance, and support for AI and edge computing. Critical thinking and original research are encouraged.			
Course outcomes	The student will be able to: a) Design complex embedded systems comprising multiple processing and peripheral units. b) Analyze, model, and optimize the performance, energy consumption, and resource utilization of embedded systems. c) Integrate and optimize AI models for real-time execution on embedded platforms. d) Investigate, apply, and critically evaluate contemporary paradigms, including RISC-V, reconfigurable computing, and heterogeneous systems-on-chip. e) Analyze, interpret, and critically assess the results of scientific research in the field of embedded systems. f) Independently formulate research problems, develop novel methods and architectural solutions, and evaluate their scientific and practical contributions.			
Course outline				
Theoretical teaching	Embedded systems versus general-purpose processors. Hardware and software design methodologies for embedded systems. Next-generation architectures: multicore processors, RISC-V, MPSoC. Constraints and challenges – high reliability, high performance, low cost, ultra-low power consumption. Embedded AI and ML accelerators. Application-specific processors. SoC design using configurable cores. Interconnection networks. Memory systems. Development and testing tools. Hardware/software co-design. Programming and code optimization. Embedded operating systems. Real-time task scheduling. Operating system selection and configuration. Testing and verification. Typical applications.			
Practical teaching (exercises, OFE, study and research work)	Research activities encompass the following areas: 1) Design and simulation of modern embedded systems based on SoC platforms (Zynq UltraScale, RISC-V). 2) Analysis of different multiprocessor system-on-chip (MPSoC) organizations. 3) Experimental investigation of parallelization techniques and optimization methods for embedded AI models, including the measurement of metrics such as execution time, throughput, energy consumption, and hardware resource utilization. 4) Hardware/software co-design, functional verification of implemented solutions, and comparative analysis of different approaches using contemporary development tools and open hardware and software platforms. 5) Critical analysis and interpretation of the obtained results in the context of current scientific advances in the field of embedded systems.			
Textbooks/references				
1	Marilyn Wolf, High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing, 2nd Edition, Morgan Kaufmann, 2014.			
2	Peter Marwedel, Embedded System Design: Embedded Systems Foundations of Cyber-Physical Systems, and the Internet of Things, Springer, 2021.			
3	Ovidiu Vermesan, Mario Diaz Nava, Björn Debaillie, Embedded Artificial Intelligence: Devices, Embedded Systems, and Industrial Applications, River Publishers, 2023.			
4	William J. Dally, Curtis Harting, Digital Design: A system approach, Cambridge University Press, 2012.			
5	Lawrence J. Henschen and Julia C. Lee, Embedded System Design: Methodologies and Issues, 1st Edition, Morgan Kaufmann, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is conducted through lectures and individual mentoring. Students participate in both independent and team-based work on solving tasks within scientific research projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50

Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		System-on-Chip Design		
Lecturer (for lectures)		Dimitrijević A. Marko		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Expansion and systematization of knowledge about the properties, architecture, and design methodologies of system-on-chip (SoC).			
Course outcomes	Students will be able to design the architecture, configure, adapt to specific applications, implement a prototype system-on-a-chip, install and adapt the operating system and application software on the implemented hardware, and apply it in various applications. Students will acquire competencies for analyzing existing solutions and developing new ones in design, and will be prepared for scientific research in the field of implementing modern systems-on-a-chip.			
Course outline				
Theoretical teaching	Modeling and specifying systems at a high level of abstraction. Analyzing system performance in the early stages of the design process. Examining the relationship between hardware and software components of system-on-chip, algorithms, and architectures to optimize the system based on requirements (specifications) and constraints. Architectures of system-on-chip (control, real-time systems, data processing). Synthesizing hardware, software, and interfaces. Simulating and verifying systems, and conducting hardware/software (HW/SW) co-simulation. Network-on-chip. Examples of applications and systems for the implementation of systems on a chip (Chisel, Magma). Reusing blocks and co-design.			
Practical teaching (exercises, OFE, study and research work)	Practical exercises cover the process of creating and configuring a RISC-V SoC: creating a RISC-V SoC in Vivado environment, creating a RISC-V SoC using FuseSoC for automated IP block connection, installing Zephyr RTOS - setting up a real-time operating system - running programs, including TensorFlow Lite - implementing machine learning on a RISC-V SoC, and applying the RISC-V architecture in practical applications.			
Textbooks/references				
	1	Michael J. Flynn, Wayne Luk, Computer System Design: System-on-Chip, 2011, John Wiley & Sons, Inc., ISBN: 978-1-118-00991-8		
	2	Veena S. Chakravarthi, Shivananda R. Koteswarar, System on Chip (SOC) Architecture: A Practical Approach, 2023, Springer Nature, ISBN: 978-3-031-36241-5		
	3	Veena S. Chakravarthi, A Practical Approach to VLSI System on Chip (SoC) Design: A Comprehensive Guide, 2nd edition, 2022, Springer Nature, ISBN: 978-3-031-18362-1		
	4	José L. Ayala, Communication Architectures for Systems-on-Chip, 2011, CRC Press, ISBN: 978-1-439-84170-9		
	5			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, laboratory work, consultations, projects			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		DSP Architectures and Algorithms		
Lecturer (for lectures)		Nikolić R. Tatjana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The objective of the course is to provide students with a critical understanding of modern processor architectures for digital signal processing (DSP), as well as the theoretical and practical aspects of implementing advanced algorithms. Special focus is placed on energy efficiency, parallelism, programmability, and hardware-software co-design to meet the requirements of high-performance systems.			
Course outcomes	The student will be able to: a) Explain, compare, and critically evaluate contemporary signal processing architectures, including heterogeneous CPU-, DSP-, and AI accelerator-based systems. b) Analyze the efficiency of different DSP architectures in the context of specific algorithms and application domains. c) Implement and optimize advanced signal processing algorithms for resource-constrained systems. d) Design, evaluate, and optimize solutions based on DSP+FPGA/ASIC platforms. e) Investigate and develop techniques for accelerating signal processing and machine learning algorithms. f) Critically analyze the results of experimental research and compare them with relevant scientific publications. g) Independently define research objectives and propose original solutions in the field of DSP architectures and algorithms.			
Course outline				
Theoretical teaching	Specific features and architectures of DSP processors. Application domains of DSPs. Data representation and arithmetic methods, effects of finite word length, programming aspects, real-time operation, and hardware interfaces. Programming DSP processors in assembly language and higher-level languages. DSP for fixed-point operation. DSP for floating-point operation. DSP for embedded applications. DSP on FPGA. DSP in heterogeneous systems – coexistence of CPU, DSP, GPU, AI accelerator. Low-power architectures. Algorithm-hardware co-design. Algorithm optimization for real-time operation. Hardware implementations: digital filters, discrete Fourier transform, CORDIC, cryptographic algorithms. DSP for signal processing in machine learning and communications domains.			
Practical teaching (exercises, OFE, study and research work)	Research activities encompass the following areas: 1) Simulation and analysis of DSP processor architectures using the Code Composer Studio (CCS) development environment. 2) Implementation and optimization of signal processing algorithms on different hardware platforms. 3) Analysis of the impact of fixed-point and floating-point arithmetic on the accuracy, complexity, and performance of algorithms. 4) Hardware implementation of selected algorithms on FPGA platforms and experimental evaluation through measurement of execution time, resource utilization, energy consumption, and processing accuracy. 5) Comparative analysis of machine learning algorithm implementations on CPU, DSP, and GPU platforms, critical interpretation of the obtained results, and comparison with results reported in relevant scientific literature.			
Textbooks/references				
1	Shoab Ahmed Khan, Digital Design of Signal Processing Systems: A Practical Approach, Wiley, 2011.			
2	Roger Woods, John McAllister, Gaye Lightbody, Ying Yi, FPGA-based Implementation of Signal Processing Systems, John Wiley & Sons, UK, 2017.			
3	Li Tan, Jean Jiang, Digital Signal Processing: Fundamentals, Applications, and Deep Learning, Elsevier, 2025.			
4	Revi Ofir, Enhancing RISC-V RVV with Custom DSP Instructions for Embedded Applications, Synopsys, 2024.			
5	Ruiz Gustavo, Michell Juan A. (editors), Design and Architectures for Digital Signal Processing, IntechOpen, 2013.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is conducted through lectures and individual mentoring. Students participate in both independent and team-based work on solving tasks within scientific research projects.			
Grade (maximum number of points 100)				

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electronic Circuits Testing		
Lecturer (for lectures)		Milić Lj. Miljana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The student will understand the mechanisms of defect formation in electronic circuits (analog, digital, and mixed-signal) and will be able to apply procedures for synthesizing test signals to test integrated and printed electronic circuits.			
Course outcomes	The student will become familiar with the causes of defects in integrated electronic circuits and will be equipped to design test signals for defect detection in integrated analog, digital, and mixed-signal circuits. Additionally, the student will master design techniques that facilitate the testing process both in laboratory settings and in mass production of integrated circuits.			
Course outline				
Theoretical teaching	Defect models in analog and digital circuits. Concurrent fault simulation. Digital circuit testing. Testing of combinational, sequential, and regular topology circuits. Test generation automation. Testing and simulation of delay faults. Testing of mixed-signal systems. Design for testability (DFT) principles. Basic concepts of Boundary Scan. Built-in self-test (BIST). Equipment for electronic circuit testing.			
Practical teaching (exercises, OFE, study and research work)	As part of the course, students undertake a practical project or a seminar paper.			
Textbooks/references				
1	Laung-Terng Wang, Cheng-Wen Wu, Xiaoqing Wen: VLSI TEST PRINCIPLES AND ARCHITECTURES, Elsevier, 2006.			
2	SAMIHA MOURAD, YERVANT ZORIAN: Principles of testing electronic systems, JOHN WILEY & SONS, 2000.			
3	uman Lata Tripathi, Sobhit Saxena, Sushanta Kumar: Advanced VLSI Design and Testability Issues, 1st Edition, SRC press, 2022.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Presentation and public defense of student research projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Reconfigurable Systems		
Lecturer (for lectures)		Jovanović D. Milica		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The course objective is to teach students with architectures and design principles of reconfigurable systems and their applications in computing and embedded systems, including: a) fundamentals of reconfigurable system design at low-, middle- and high-level of abstraction; b) practical aspects of reconfigurable computing and implementation constraints; c) typical applications of reconfigurable systems.			
Course outcomes	The acquired advanced theoretical knowledge and practical experience enable students to design, implement, and evaluate fully and partially reconfigurable systems using contemporary FPGA technologies, tools, and development platforms. Upon successful completion of the course, students are qualified to critically analyze scientific results, independently formulate and conduct research, and develop new methods and solutions as well as improve existing ones in the field of reconfigurable systems.			
Course outline				
Theoretical teaching	Introduction to Reconfigurable Systems. Overview of the architecture of modern FPGA circuits. Trends of development. Design flow, methodologies and design tools. Optimization of the HDL code for FPGA synthesis from the aspect of performance, complexity and energy consumption. Mapping RTL structures to FPGA and implementation: scheduling and binding. Coarse-grained reconfigurable systems and multi-FPGA systems. Hybrid architectures: soft-microprocessors, hardware/software codesign. Comparison of FPGA and multicore architectures. Implementation of arithmetic circuits in FPGA. Applications of reconfigurable systems in fields of: bioinformatics, digital signal processing, image processing, cryptography, molecular dynamics, fluid dynamics, and high-reliability systems. Advanced Topics: dynamic reconfigurability, and partial reconfigurability.			
Practical teaching (exercises, OFE, study and research work)	Research activities include the analysis and comparison of contemporary FPGA architectures, tools, and design methodologies for reconfigurable systems, as well as the critical review of scientific literature in the areas of dynamic and partial reconfiguration, hybrid FPGA architectures, and applications of reconfigurable computing. Students independently define experiments, design and implement selected solutions on FPGA platforms, and perform measurement and analysis of parameters such as resource utilization, maximum operating frequency, power consumption, and system performance. Based on the obtained results, they conduct comparative analyses with existing solutions reported in the literature, interpret the results using appropriate evaluation methods, and formulate conclusions regarding opportunities for improving architectures, design methodologies, and application domains of reconfigurable systems.			
Textbooks/references				
	1	S. Hauck, A. DeHon, Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation, 2008.		
	2	S. Kilts, Advanced FPGA Design, Architecture, Implementation, and Optimization, John Wiley & Sons, Inc., 2007.		
	3	M. Wijnvliet, H. Corporaal, and A. Kumar, Blocks: Towards Energy-Efficient, Coarse-Grained Reconfigurable Architectures, Cham, Switzerland: Springer, 2021.		
	4	Skliarova, I., Brox Jiménez, P., Véstias, M., & Diniz, P. C. (Eds.). Applied Reconfigurable Computing: Architectures, Tools, and Applications. 20th International Symposium, ARC 2024, Faro, Portugal, April 10–12, 2024, Proceedings. Lecture Notes in Computer Science, vol. 14553. Cham, Switzerland: Springer, 2024		
	5	Giorgi, R., Stojilović, M., Stroobandt, D., Brox Jiménez, P., & Barriga Barros, Á. (Eds.). Applied Reconfigurable Computing: Architectures, Tools, and Applications. 21st International Symposium, ARC 2025, Barcelona, Spain, April 2–4, 2025, Proceedings. Lecture Notes in Computer Science. Cham, Switzerland: Springer, 2025.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0

Teaching methods	Lectures, tutorial sessions, projects, and consultations.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Synthesis of Filters		
Lecturer (for lectures)		Nikolić V. Saša, Stančić Z. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Expansion and development of basic knowledge acquired in the field of synthesis of analog and digital filters. Adoption of new approximation techniques. Getting to know modern techniques for the synthesis and implementation of adaptive filters. Analysis of the influence of finite word length.			
Course outcomes	Students will acquire the necessary level of theoretical and practical skills to respond to any concrete questions that are raised in designing, modeling, performance evaluation, estimation, realization, practical application and verification of filter systems. Students gain knowledge on how to implement a filter that processes signals according to precisely given specifications.			
Course outline				
Theoretical teaching	Passive filter synthesis. Synthesis of polynomial filters. Synthesis of filters with finite transmission zeros. Synthesis of minimal phase filters. Filters with distributed parameters. Synthesis of active RC filters. Filter configurations. Basic filter configurations. Filters realization. Properties of different configurations. Sensitivity. Decomposition. Assessment of the hardware complexity of different configuration for the implementation of digital filters. Adaptive filtering.			
Practical teaching (exercises, OFE, study and research work)	Application of the Matlab program package to the analysis and synthesis of various analog and digital filters.			
Textbooks/references				
1	S. Mitra: Digital signal processing, a computer based approach, McGraw-Hill, 2006			
2	J.G. Proakis, D. Manolakis: Digital Signal Processing, Pearson, 2007.			
3	A. Antoniu: Digital filters: analysis, design and applications, the second edition, Prentice-Hall.			
4	C.F. Marzolo: Analog Filters Handbook using APL-2, Springer, 2025			
5	T. Hinamoto, W.S. Lu: Digital Filter Design and Realization, River Publishers, 2024			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, auditive exercises, laboratory exercises, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	60
Colloquia				
Projects		40		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Computer Vision		
Lecturer (for lectures)		Cvetković S. Stevica		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The goal of this course is to provide students with a deep understanding of modern methods and techniques in the field of digital image and video analysis and interpretation, with a particular emphasis on the application of deep neural networks.			
Course outcomes	By the end of the course, students are expected to be able to independently design algorithms in the field of computer vision, as well as to train and apply advanced deep learning models for the analysis of visual data.			
Course outline				
Theoretical teaching	Through lectures, students will gain knowledge of the theoretical foundations of computer vision, starting with an overview of image processing operations (edge detection, segmentation, feature extraction), as well as advanced methods such as object detection, tracking, scene reconstruction, and activity recognition. Special emphasis will be placed on deep convolutional neural networks (CNNs) and architectures such as ResNet, YOLO, U-Net, and ViT, as well as on transfer learning techniques, data augmentation, and model optimization. Applications in the fields of autonomous driving, medical diagnostics, intelligent surveillance, and augmented reality will be analyzed through case studies.			
Practical teaching (exercises, OFE, study and research work)	During practical sessions, students will implement models using popular tools such as Python, OpenCV, PyTorch, and TensorFlow. The course also includes critical analysis of scientific papers from leading conferences and a project in which students solve a real-world problem in the field of computer vision. By the end of the course, students are expected to be able to independently design, train, and apply advanced models for tasks in machine perception and visual data analysis.			
Textbooks/references				
1	Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, 2022.			
2	David A. Forsyth, Jean Ponce, "Computer Vision: A Modern Approach", 2nd edition, 2011.			
3	Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, 2016.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, seminars, assignments, and class discussions			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	20	Written exam		
Exercises	20	Oral exam		40
Colloquia				
Projects	20			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Ultrasonic Technique		
Lecturer (for lectures)		Mančić D. Dragan, Jovanović D. Igor		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Expanding and upgrading the fundamental knowledge acquired in the field of ultrasonic technique and guidance towards the adoption of new techniques required by concrete and specific applications which are subject of interest to students.			
Course outcomes	Students gain the necessary theoretical and practical knowledge to meet any specific request in development, modeling, performance assessment, optimization, realisation, control, practical application and verification of the various devices of ultrasonic technique mainly of the various sandwich transducers and electronic generators.			
Course outline				
Theoretical teaching	Piezoelectric ceramics. Modelling of piezoelectric ceramics. Development of ultrasonic waveguide concentrators and sonotrodes. Modeling of metal resonators. Development, modeling and optimization of the power ultrasonic transducers. Development, modeling and optimization of the power electronic ultrasonic generators. Basic applications of power ultrasound. Ultrasonic systems for cleaning and welding.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	M.Radmanović, D.Mančić, "Design and modeling of powerful ultrasonic transducers", Faculty of Electronics, Niš, 2004.			
2	J.David, N.Cheeke, "Fundamentals and Applications of Ultrasonic Waves", CRC Press, 2012.			
3	J.A Gallego-Juarez, KF Graff, "Power Ultrasonics: Applications of High-Intensity Ultrasound", Elsevier, 2015.			
4	D. Ensminger, LJBond, "Ultrasonics: Fundamentals, Technologies, and Applications", CRC Press, 2011.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is held in lectures while simultaneously mentoring students. Individual and team work of students takes place during their practical and scientific and research work on the defined projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Solid State Physics		
Lecturer (for lectures)		Ristić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Introducing students to basic processes in solid states, including conductors, semiconductors and dielectrics.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to recognize and analyze the structure and properties of solid states, as well as the transport of charge carriers.			
Course outline				
Theoretical teaching	Theoretical lectures will take place in the following areas: Physical characteristics and classification of solid states, crystal lattices, interatomic connections, zonal theory of solid states, electronic states in a periodic crystal, thermal motion of the crystal lattice, transport and optical charecteristics, properties of dielectrics. Semiconductors, electronic transport processes, diffusion and recombination processes. Magnetic properties of solid bodies. Superconductivity.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	P. Hofmann, "Solid State Physics: An Introduction", 3rd ed. Weinheim, Germany: Wiley-VCH, 2022, ISBN 978-3-527-41411-6		
	2	R. L. Stamps, R. E. Camley, and R. Macêdo, Eds., "Solid State Physics", Volume 77, 1st ed. San Diego, CA, USA: Academic Press, 2026. ISBN: 978-0-443-47182-7.		
	3	N. W. Ashcroft and N. D. Mermin, "Solid State Physics", Reprint ed. Boston, MA, USA: Cengage Learning, 2021. ISBN: 978-0-030-83993-1.		
	4	S. M. Sze and K. K. Ng, "Physics of Semiconductor Devices", 3rd ed. New Delhi, India: Wiley India, 2015. ISBN: 978-8-126-51702-2.		
	5	C. Kittel, "Introduction to Solid State Physics", Global ed. Hoboken, NJ, USA: Wiley, Jun. 2018. ISBN: 978-1-119-45416-8.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		60
Colloquia	40			
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Physics of Ionized Gases		
Lecturer (for lectures)		Ristić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Get to know the basic processes that lead to the formation of charged particles in the gas and their transport. Getting to know about the breakdown of gases, tinnitus, sparks, coronas and arched discharge.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to analyze the process of the formation and transport of charged particles into a low ionized gas.			
Course outline				
Theoretical teaching	Theoretical lectures will take place in the following areas: Formation and disappearance of particles into a weakly ionized gas. Drift, energy and diffusion of charged particles. Breakdown in gases in the fields of different frequency band. Stable and unstable dissipation. Spark, corona and arched discharge. Solving the kinetic equation in a weakly ionized gas in the presence of an electric field. Physical mechanisms that lead to discharge and which are present in various types of discharge.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	M. I. Boulos, P. Fauchais, and E. Pfender, "High-Pressure Flows for Thermal Plasma Production", 1st ed. Cham, Switzerland: Springer, June 2023. doi: 10.1007/978-3-031-27361-2.			
2	N. Sadeghi and J. P. Booth, "Kinetics and Spectroscopy of Low-Temperature Plasmas", 1st ed. Cambridge, UK: Cambridge University Press, 2022. doi: 10.1017/9781108873406.			
3	F. F. Chen, "Introduction to Plasma Physics and Controlled Fusion", 4th ed. New York, NY, USA: Springer, 2021. doi: 10.1007/978-3-319-22149-6.			
4	J. M. Meek and J. D. Craggs, "Electrical Breakdown of Gases", Reprint ed. London, UK: Legare Street Press, Oct. 2022. ISBN: 978-1015450684.			
5	M. Abdel-Salam, "Electrical Breakdown of Gases," in High-Voltage Engineering, 2nd ed. Boca Raton, FL, USA: CRC Press, 2020/2021. doi: 10.1201/9781482290035-4.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		60
Colloquia	40			
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Photonics		
Lecturer (for lectures)		Živanović N. Emilija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Ensuring understanding of the dual nature of light and its characteristics (generation, transport, manipulation, detection, and application).			
Course outcomes	Preparing students to work in the field of photonics and related disciplines (electron optics, optoelectronics), with an understanding of the vital role of light across a wide range of domains, along with the ability to develop and master new techniques and knowledge.			
Course outline				
Theoretical teaching	Theoretical foundations of wave-particle duality. The electromagnetic nature of light. Spectra. Interference, diffraction, and polarization. Interaction between light and matter. The particle nature of light and other electromagnetic radiation. Maxwell's equations and their applications. The photoelectric and Compton effects. Principles of operation of optical instruments. Non-laser and laser light and their applications in various branches of science. Fundamentals of quantum physics.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Safa O. Kasap, Optoelectronics and Photonics: Principles and Practices, Prentice Hall, 2001.			
2	Raymond A. Serway, John W. Jewett, Jr., Physics for scientists & engineers with modern physics, tenth Edition, Cengage, 2018.			
3	Bahaa E. A. Saleh, Malvin Carl Teich, Fundamentals of Photonics, Wiley, 2020.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching takes place through lectures, auditory and consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Radiation Physics		
Lecturer (for lectures)		Ristić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Introducing students with ionizing and non-ionizing radiation, radiation detection, biological effects and radiation protection.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to recognize the types of radiation, their influence on living and non-living matter, and methods for radiation detection, and protection against radiation.			
Course outline				
Theoretical teaching	Sources and types of radiation, classification of radiation. Ionizing radiation: particulate and electromagnetic, dosimetric quantities and units, interaction of radiation with matter, effect of radiation on living matter, radiation detection. Principle of operation and description of different types of ionizing radiation dosimeters. Non-ionizing radiation (radio-frequency and optical): properties, quantities and units, measurement and instruments for measuring radiation fields, biological effects.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	D. K. Aswal, Ed., "Handbook on Radiation Environment", Volume 2: Dose Measurements. Singapore: Springer Nature Singapore, 2024.			
2	P. Andreo, D. T. Burns, A. E. Nahum, J. Seuntjens, and F. H. Attix, "Fundamentals of Ionizing Radiation Dosimetry: Textbook and Solutions". Weinheim, Germany: Wiley-VCH, 2021.			
3	M. Ljungberg, "Radiation Physics for Nuclear Medicine", 2nd ed. Cham, Switzerland: Springer, 2023. doi: 10.1007/978-3-031-21392-2.			
4	S. R. Cherry, J. A. Sorenson, and M. E. Phelps, "Principles of Radiation Physics", 1st ed. Philadelphia, PA, USA: Elsevier, 2022. ISBN: 978-0-323-79114-4.			
5	K. N. Prasanna Kumar, "Advanced Radiation Physics", 1st ed. New Delhi, India: I K International Publishing House, 2021. ISBN: 978-93-90620-11-1.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	60
Colloquia		40		
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electrical discharge of gases		
Lecturer (for lectures)		Živanović N. Emilija, Pejović M. Milić		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		To introduce students to research focused both on understanding the physical processes occurring during electrical breakdown and discharge, and on their practical applications. Additional emphasis will be placed on the practical application of various types of gas components. The course includes characterization of gas components, measurement methods, and statistical analysis of the obtained experimental results.		
Course outcomes		Acquisition of theoretical and practical knowledge enabling the characterization of components, mastering of measurement techniques, and statistical analysis of the obtained experimental results.		
Course outline				
Theoretical teaching		The course will cover the following topics. Electrical breakdown and discharge in gases. Processes in noble gases, nitrogen, and air. Processes at electrodes. Breakdown probability. Breakdown voltage. Delay time of electrical breakdown. Statistical delay time. Discharge formative time. Analysis of memory effects in gases based on memory curves. Techniques and systems for measuring breakdown voltage and breakdown delay time in gases.		
Practical teaching (exercises, OFE, study and research work)		Practical classes are held in the Laboratory for Gas and Vacuum Technology. Students will be introduced to and shown demonstrations of existing electronic systems for testing and characterizing various types of gas components. There will be opportunities to develop parts of or complete systems. Testing of gas components and statistical processing of the results will also be carried out.		
Textbooks/references				
1		Y. P. Rayzer, Gas Discharge Physics, Berlin: Springer, 1991		
2		Eduard M. Bazelyan, Yuri P. Raizer, Lightning Physics and Lightning Protection, Institute of Physics Publishing, Bristol and Philadelphia, 2000.		
3		Vladislav Mazur, Principles of Lightning Physics, IOP Publishing, Bristol, UK, 2016.		
4		J. M. Meek and J. D. Craggs, "Electrical Breakdown of Gases", Reprint ed. London, UK: Legare Street Press, Oct. 2022. ISBN: 978-1015450684.		
5		G. Poparić, B. Obradović, and D. Borka, Eds., "The Physics of Ionized Gases". Basel, Switzerland: MDPI, Mar. 2019. doi: 10.3390/books978-3-03897-623-3.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching takes place through lectures, laboratory exercises and consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises		10	Oral exam	50
Colloquia		20		
Projects		20		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Devices of Vacuum and Gas Electronics		
Lecturer (for lectures)		Ristić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to students with the types and principles of work of modern components of vacuum and gas electronics.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to determine the physical fundamentals of mechanisms and processes used in modern components of vacuum and gas electronics, as well as to explain the principles of their work.			
Course outline				
Theoretical teaching	Theoretical lessons will be delivered through lectures in the following areas: electrons in electric and magnetic fields, electronic emissions, electronic cannons and mirrors. Electronic tubes controlled by gratings. Microwave components and circuits. Clistrons, multiplying components. Photoelectronic components, voltage regulating tubes, gas rectifier tubes, tiratrons, plasma displays, gas sources of light.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	J. Kumar and S. K. Datta, "Microwave Vacuum Electronic Devices: Enabling Concepts", 1st ed. Bristol, UK: IOP Publishing, Nov. 2025.			
2	J. Feng, F. Li, and J. Wang, Eds., "High-Frequency Vacuum Electron Devices". Basel, Switzerland: MDPI, 2022. doi: 10.3390/books978-3-0365-5388-7.			
3	C. Paoloni, "Vacuum Electronic Devices," in High Capacity Wireless Links: From Millimeter-Waves to THz, E. Limiti and A. Cidronali, Eds. Cham, Switzerland: Springer, 2021, pp. 583–604. doi: 10.1007/978-3-030-73738-2_27.			
4	W. Huang, Ed., "Design, Technologies and Applications of High Power Microwave Sources". Basel, Switzerland: MDPI, 2021. doi: 10.3390/books978-3-0365-2241-8.			
5	G. Poparić, B. Obradović, and D. Borka, Eds., "The Physics of Ionized Gases". Basel, Switzerland: MDPI, Mar. 2019. doi: 10.3390/books978-3-03897-623-3.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	60
Colloquia		40		
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Medical Physics		
Lecturer (for lectures)		Ristić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Introduction to the use of ionizing and non-ionizing radiation in medicine, as well as the principle of basic methods of medical diagnostics.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to recognize diagnostic and therapeutic methods in medicine based on ionizing and non-ionizing radiation, as well as devices used for this purpose.			
Course outline				
Theoretical teaching	Medical diagnostics. X-rays and X-ray characteristics and their application in medicine. Radiography and fluoroscopy, mammography, X-ray, computer tomography. Digital Flat Panel X-ray Appliances. The production and the characteristics of ultrasound and its application in medicine. Principle of magnetic resonance, and its application in medical diagnostics. Use of radioisotopes in medical diagnostics and radiotherapy. PET diagnostics. Electrocardiography, Laser application in medicine. Application of radiofrequency and optical radiation in medical diagnostics and therapy. Radiotherapy devices.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	S. Keevil, R. Padovani, S. Tabakov, T. Greener, and C. Lewis, Eds., "Introduction to Medical Physics", 1st ed. Boca Raton, FL, USA: CRC Press, 2022. ISBN: 978-1498744799.		
	2	M. Ljungberg, "Radiation Physics for Nuclear Medicine", 2nd ed. Cham, Switzerland: Springer, 2023. doi: 10.1007/978-3-031-21392-2.		
	3	J. Andersson and J. Nilsson, "Diagnostic Radiology Physics with MATLAB: A Practical Approach", 1st ed. Boca Raton, FL, USA: CRC Press, 2021. ISBN: 978-0367370343.		
	4	K. Wells and H. C. Gifford, Eds., "Webb's Physics of Medical Imaging", 3rd ed. Boca Raton, FL, USA: CRC Press, 2024. ISBN: 978-1138593305.		
	5	M. Markov, Ed., "Dosimetry in Bioelectromagnetics", 1st ed. Boca Raton, FL, USA: CRC Press, 2017. doi: 10.1201/9781315154749.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	70
Colloquia				
Projects		30		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Semiconductor Devices and Technologies		
Lecturer (for lectures)		Prijić P. Aneta		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The objectives of the course are focused on: - Detailed analysis of physical processes in semiconductor materials; - In-depth study of the structure and principles of the basic semiconductor devices functioning; - Introduction to the structures and functioning principles of semiconductor devices based on heterojunctions and compound semiconductors; - Understanding the functioning of microwave and photovoltaic components; - Introduction to advanced technologies for semiconductor devices and integrated circuits fabrication.			
Course outcomes	Learning outcomes allow a student to: - Visualize the effects of high doping of the semiconductors through the concept of energy bands; - Explain the interdependence of relations that describe the concentrations and transport of charge carriers in the semiconductors; - Analyze secondary physical and electrical effects that affect the functioning of basic semiconductor devices; - Compare the functioning principles of semiconductor devices based on heterojunctions and semiconductor compounds with basic semiconductor devices; - Explain the functioning of microwave and photovoltaic devices; - Specifies the unique properties of advanced semiconductor devices fabrication techniques.			
Course outline				
Theoretical teaching	Energy bands and equilibrium carrier concentrations. Effects of heavy doping of semiconductors. Transport of charge carriers. Diodes. Silicon bipolar transistors. Heterojunction bipolar transistors. Modeling of bipolar transistors. Field effect transistors based on semiconductor compounds. GaAs MESFETs. Heterojunction Field Effect Transistors (HFETs). MOSFET transistors. CMOS/BiCMOS. SOI and 3D structures. Microwave devices. Photovoltaic devices. Monocrystalline silicon fabrication and epitaxial growth. Oxidation and thin films growth. Diffusion and ion implantation. Photolithography and etching. Encapsulation of devices.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	S. Sze, Y. Li, K. Ng, "Physics of Semiconductor Devices", 3rd ed., Wiley, 2021 - selected chapters.			
2	D. Neaman, "Semiconductor Physics and Devices", 4th ed., McGraw-Hill, 2011 - selected chapters.			
3	B.-L. Anderson, R. Anderson, "Fundamentals of Semiconductor Devices", 2nd ed., McGraw-Hill Education, 2018 - selected chapters.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Inclusion in the teaching process at bachelor and master academic studies; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises		30	Oral exam	40

Colloquia			
Projects	30		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Sensors and Actuators		
Lecturer (for lectures)		Vračar M. Ljubomir, Pejović M. Milić		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Acquiring the knowledge for understanding and application of modern sensors and actuators.			
Course outcomes	Upon successful completion of this doctoral course, the student will be able to critically evaluate the latest scientific achievements in the field of sensors and transducers, conceptualize and develop innovative methods and energy conversion principles for advanced measurement systems, as well as independently lead scientific research projects, experimentally verify original technological solutions, and formulate results for publication in top-tier international journals.			
Course outline				
Theoretical teaching	Classification and terminology of sensors and actuators. Signal processing. Most important sensor types: magnetical, radiation, thermal, mechanical and chemical. Most important actuator types: linear and rotary electromechanical converters, displays, electrical converters. Interface methodologies and circuits. Integration aspects. Manufacturing techniques and material properties. Applications of sensors and actuators.			
Practical teaching (exercises, OFE, study and research work)	The laboratory exercises include courses on sensors operation and electrical characteristics found in practice. Especially, the introductory course is aimed to educate students with programming microcontrollers for data processing from different sensor devices.			
Textbooks/references				
1	JACOB FRADEN, "HANDBOOK OF MODERN SENSORS: PHYSICS, DESIGNS, and APPLICATIONS" Third Edition, 2011, Springer-Verlag, In Jon S. Wilson (ed.), "Sensor Technology Handbook" Newnes, Elsevier Inc, 2005			
2	R. Frank, Ed., Understanding smart sensors, 2nd ed. in Artech House sensors library. Boston: Artech House, 2000.			
3	P. Gründler, Chemical sensors: an introduction for scientists and engineers. Berlin: Springer, 2007			
4	K. Poletkin, L. A. Francis, and K. Iniewski, Eds., Magnetic sensors and devices: technologies and applications. in Devices, circuits, and systems. Boca Raton London New York: CRC Press, Taylor & Francis Group, CRC Press is an imprint of the Taylor & Francis Group, an informa business, 2018.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Auditorial teaching, Laboratory exercise, student tutorials			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	10	Written exam		
Exercises		Oral exam		60
Colloquia				
Projects	30			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Technological Processes in Gasses and Vacuum		
Lecturer (for lectures)		Ristić S. Goran, Živanović N. Emilija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)		Elective
Prerequisites	None			
Course objectives	The acquisition of theoretical knowledge about gases and vacuum in order to introduce to certain technological processes (with particular emphasis on technological processes in microelectronics).			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to recognize technological processes that occur in gases and vacuum, especially the technological processes in the production of microelectronic devices.			
Course outline				
Theoretical teaching	The properties of gases. Molecular phenomena in the gas. Transport processes in gas. The adsorbed gases. Electric currents in gases. Pumping and vacuum pumps. Measuring the low-pressure gas and vapor. Vacuum systems. Vapor deposition. Nitriding. Cleaning surfaces. Plasma metallurgy. Plasma processes in microelectronics. The properties of gases. Molecular phenomena in the gas. Transport processes in gas. The adsorbed gases. Electric currents in gases. Pumping and vacuum pumps. Measuring the low-pressure gas and vapor. Vacuum systems. Vapor deposition. Nitriding. Cleaning surfaces. Plasma metallurgy. Plasma processes in microelectronics.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	J. F. O'Hanlon and T. A. Gessert, "A User's Guide to Vacuum Technology", 4th ed. Hoboken, NJ, USA: John Wiley & Sons, Oct. 2023. ISBN: 978-1119851417.		
	2	M. I. Boulos, P. Fauchais, and E. Pfender, "High-Pressure Flows for Thermal Plasma Production", 1st ed. Cham, Switzerland: Springer, June 2023. doi: 10.1007/978-3-031-27361-2.		
	3	Z. H. Barber, "Thin Film Growth: Physics and Technology", 2nd ed. Cambridge, UK: Cambridge University Press, 2022. ISBN: 978-1108488341.		
	4	H. O. Pierson and J.-O. Carlsson, "Handbook of Chemical Vapor Deposition (CVD): Principles, Technology, and Applications", 5th ed. Oxford, UK: William Andrew / Elsevier, June 2024. ISBN: 978-0128243220.		
	5	N. Sadeghi and J. P. Booth, "Kinetics and Spectroscopy of Low-Temperature Plasmas", 1st ed. Cambridge, UK: Cambridge University Press, 2022. doi: 10.1017/9781108873406.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		60
Colloquia	40			
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electromagnetics		
Lecturer (for lectures)		Raičević B. Nebojša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The objective of the course is to deepen and systematize knowledge in the field of electromagnetics, with particular emphasis on analytical and numerical methods for modeling electromagnetic fields and waves, as well as to enable students to independently apply, critically analyze, and develop methods for solving complex research and engineering problems.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently model and analyze complex problems in electromagnetics using Maxwell's equations in both time and frequency domains, apply analytical and numerical methods for solving electromagnetic fields, critically analyze and verify obtained results by comparison with theoretical models and literature, and interpret results in the context of the development and optimization of electromagnetic systems.			
Course outline				
Theoretical teaching	Electrostatics. Stationary and time-varying electromagnetic fields. Maxwell's equations in integral and differential forms. Maxwell's equations in the complex domain. Electromagnetic properties of media. Boundary conditions. Electromagnetic field potentials. Poynting's theorem. Analytical methods for electromagnetic field calculation – method of separation of variables, use of complex variable functions. Numerical methods – finite difference method, finite element method. Plane electromagnetic waves (in vacuum, dielectrics, imperfect conductors, ferrites, and layered media). Field polarization. Propagation of electromagnetic waves. Fresnel coefficients. TEM, TE, and TM guided waves.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	F. T. Ulaby, "Fundamentals Applied Electromagnetics", Pearson, Prentice Hall, New York, 2010.			
2	M. Sadiku, „Numerical techniques in Electromagnetics“, CRC Press, 2001.			
3	D. M. Veličković, F. H. Uhlmann, K. Brandisky, R. D. Stancheva, H. Brauer, "Fundamentals of Modern Electromagnetics for Engineering", TU Ilmenau, Germany, 2005.			
4	H. Neff, "Introductory Electromagnetics", John Wiley & Sons, 1991.			
5	E. Rothwell, M. Cloud, "Electromagnetics", CRC Press, 2001.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentoring work; Seminar papers with presentation.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	20	Written exam		
Exercises		Oral exam		40
Colloquia				
Projects	40			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electric Circuits Theory		
Lecturer (for lectures)		Vučković N. Ana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Development of advanced theoretical and research competencies for the analysis, modeling, synthesis, and computer simulation of complex electric circuits and networks, using analytical, numerical, and software methods, with critical evaluation of the obtained results.			
Course outcomes	Upon completion of the course, the student is able to independently formulate and solve complex scientific research and engineering problems in the field of electric circuit analysis and synthesis; apply and improve topological, analytical, numerical, and software methods in the time and frequency domains; develop, verify, and validate models of electric circuits and networks; critically analyze scientific results, evaluate the limitations of applied methods, and propose new or improved solutions; interpret, document, and present research results in the form of a scientific paper or research report.			
Course outline				
Theoretical teaching	Theoretical instruction includes a systematic and in-depth analysis of modern methods of electric circuit theory, including topological analysis, matrix methods, formulation of circuit equations, modeling in the time and frequency domains, and analytical and numerical procedures. The course considers the principles of selecting and developing mathematical models, verifying their accuracy and stability, and comparing them with analytical solutions, literature results, and reference models. Special emphasis is placed on critical analysis of scientific results, identification of limitations of existing approaches, and development of competencies for independently formulating research problems and methodological frameworks in electric circuit theory.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Charles K. Alexander, Matthew N. O. Sadiku, Fundamentals of Electric Circuits, Published by McGraw-Hill, 2012.			
2	Bird J.: Bird's Electrical Circuit Theory and Technology, 7th ed., Routledge, New York, 2021, ISBN 978-0-367-67222-5.			
3	Leonard S. Bobrow, Fundamentals of Electrical Engineering, Oxford University press, 1996.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Interactive lectures, individual and group consultations, mentoring, critical analysis of scientific papers, computer modeling and simulations, preparation and public presentation of a seminar or research paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Antennas and Electromagnetic Waves Propagation		
Lecturer (for lectures)		Raičević B. Nebojša, Perić T. Mirjana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The objective of the course is to deepen knowledge in the field of electromagnetic wave propagation and antennas, as well as to enable students to independently apply analytical and numerical methods in modeling, analysis, and optimization of radiating structures and wave propagation systems in complex environments.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently model and analyze electromagnetic radiation and wave propagation using Maxwell's equations and appropriate analytical and numerical methods, analyze radiation from different antennas and antenna systems, including dipoles, apertures, reflector and layered structures, critically evaluate wave propagation characteristics in real environments (atmosphere, ionosphere, surface and space waves), and interpret and verify simulation and measurement results in the context of scientific research in the field of antenna systems and radio wave propagation.			
Course outline				
Theoretical teaching	Electromagnetic properties of media. Spherical, cylindrical, and plane electromagnetic waves (in free space, dielectrics, and layered media). Wave polarization. Propagation of EM waves. Fresnel coefficients. TEM, TE, and TM guided waves. Electromagnetic radiation and antennas. Hertzian dipole. Hallen's integral equation. Pocklington's equation. Radiation function. Antenna gain. Radiation resistance. Transmitting and receiving antennas. Basic types of antennas. Current distribution in antennas. Antenna systems. Radiating surfaces. Radio wave propagation.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	F. T. Ulaby, "Fundamentals Applied Electromagnetics", Pearson, Prentice Hall, New York, 2010.			
2	A. R. Harish, M. Sachidananda, "Antennas and Wave Propagation", Oxford University Press, 2007.			
3	S. Orfanidis, "Electromagnetic Waves and Antennas", Rutgers University, 2004.			
4	T. Milligan, "Modern Antenna Design", IEEE Press, 2005.			
5	J. Kong, "Electromagnetic Wave Theory", EMW Publishing, 2008.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentoring work; Seminar papers			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electromagnetic Compatibility		
Lecturer (for lectures)		Cvetković N. Nenad, Perić T. Mirjana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Objective of the course is to deepen theoretical and practical knowledge in the field of electromagnetic compatibility and to enable students to independently analyze, model, and solve complex EMC problems, as well as to develop and critically evaluate methods and technical solutions in the design of electronic, communication, and power systems in accordance with applicable standards and electromagnetic compatibility requirements.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently analyze and critically evaluate electromagnetic compatibility problems, apply and develop methods for reducing electromagnetic interference, design systems and devices in accordance with EMC requirements and standards, interpret simulation and measurement results, and formulate and conduct original research in the field of electromagnetic compatibility.			
Course outline				
Theoretical teaching	Sources of electromagnetic interference. Definitions of the terms EMC, EMI, EMD, EMS. Requirements, regulations, and standards in various fields. Limitations and advantages of applying EMC requirements. Circuit and device design in accordance with EMC requirements. Transmission of interference via EM fields and conductive paths. Design principles and techniques. Selection of configurations and components. Separation, shielding, grounding, filtering. Cables, connectors, contact protection. Protective chokes for current limitation and chokes for harmonic reduction to improve power quality. Electrostatic discharge and practical solutions for related problems. Interference in power systems and EMC requirements.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	H. W. Ott, "Electromagnetic compatibility engineering", John Wiley & Sons, 2011.			
2	F. Lattarulo, "Electromagnetic compatibility in power systems", Elsevier, 2007.			
3	C. R. Paul, "Introduction to electromagnetic compatibility", John Wiley & Sons, 2006.			
4	D. Poljak, "Advanced Modeling in Computational Electromagnetic Compatibility", Wiley & Sons, 2007.			
5	T. Williams, K. Armstrong, "Electromagnetic compatibility for systems and installations", Newnes, 2000.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentorship, and independent seminar work with presentation.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Static Electricity		
Lecturer (for lectures)		Raičević B. Nebojša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		The objective of the course is to deepen knowledge of the phenomena of static electricity in technological and industrial processes, as well as to enable students to model, analyze, and quantitatively assess the generation and discharge of static charge, perform risk assessment, and develop methods for its control and elimination in complex technical systems.		
Course outcomes		Upon successful completion of the course, the student is qualified to independently model and analyze phenomena of static electricity in technological processes, quantitatively assess the conditions for the generation and discharge of static charge, analyze ignition mechanisms of flammable mixtures and risks of electrostatic discharges, apply and evaluate methods for measuring electrostatic fields, charges, and potentials, as well as to develop and critically assess protection measures and strategies for eliminating static electricity in industrial systems.		
Course outline				
Theoretical teaching		Occurrence of static electricity in technological processes. Theory of ignition of flammable mixtures. Theory of static electricity discharge from conductive and dielectric surfaces. Generation of high voltage. Modeling of industrial and electrostatic filters. Hazards of electrostatic electricity during transportation and storage of flammable and explosive materials. Techniques for measuring electrostatic charges, fields, and potentials. Protective measures and elimination of static electricity in technological processes.		
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1		G. Lüttgens, N. Wilson, "Electrostatic Hazards", Oxford: Butterworth – Heinemann, 1997.		
2		D. M. Taylor, P. E. Secker, "Industrial Electrostatics: fundamentals and measurements", J. Wiley, Research Studies Press: New York, 1994.		
3		L. G. Britton, "Avoiding Static Ignition Hazards in Chemical Operations", American Institute of Chemical Engineers, New York, 1999.		
4		J. T. Leonard, "Generation of Electrostatic Charge in Fuel Handling Systems: A Literature Survey", NRL Report 8484, Naval Research Laboratory, Washington DC, 1981.		
5		G. Lüttgens, S. Lüttgens, W. Schubert, "Static electricity", Wiley-VCH, 2017.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentoring work; Seminar papers			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Methods for Steady-state Electromagnetic Fields Calculation		
Lecturer (for lectures)		Cvetković N. Nenad, Perić T. Mirjana, Vučković N. Ana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Objective of the course is to deepen theoretical and methodological knowledge in the field of analytical and numerical methods for solving stationary electromagnetic field problems, as well as to enable students to independently develop, implement, critically evaluate, and apply modern methods and software tools in scientific research and in solving complex engineering problems.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently formulate and solve complex research problems in the field of stationary electromagnetic fields using analytical and numerical methods, develop and implement their own algorithms and software tools, critically analyze and verify obtained results by comparison with literature and numerical or experimental reference models, and identify opportunities for improving existing methods and formulate original scientific contributions.			
Course outline				
Theoretical teaching	General theory of electromagnetic fields. Classification of electromagnetic problems with respect to time dependence. Equations of stationary electromagnetic fields. Analytical methods (shape theorem, method of separation of variables, use of complex variable functions (conformal mapping)). Approximate and numerical methods (estimation method, mean potential method, finite difference method, finite element method, boundary element method, method of fictitious sources, equivalent electrode method). Development and application of custom software tools and the use of commercial software for electromagnetic field analysis.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	M. Sadiku, „Numerical techniques in Electromagnetics“, CRC Press, 2001.			
2	Z. Popović, B. Popović, "Introductory Electromagnetics", Prentice-Hall, 2000.			
3	F. T. Ulaby, "Fundamentals Applied Electromagnetics", Pearson, Prentice Hall, New York, 2010.			
4	E. Rothwell, M. Cloud, "Electromagnetics", CRC Press, 2001.			
5	D. Poljak, C. A. Brebbia, "Boundary Element Methods for Electrical Engineers", WIT Press, 2005.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentorship, and independent seminar work with presentation.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Inverse problems in Electromagnetics		
Lecturer (for lectures)		Raičević B. Nebojša, Perić T. Mirjana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The objective of the course is to acquire knowledge about the formulation and solution of inverse problems in electromagnetics, as well as to enable students to apply modern optimization and numerical methods in modeling, analysis, and solving complex electromagnetic engineering and research problems.			
Course outcomes	Upon successful completion of the course, the student is qualified to formulate and solve inverse problems in electromagnetics using optimization and numerical algorithms, apply deterministic, stochastic, and evolutionary optimization methods, including multi-objective and Pareto optimization, analyze model sensitivity to parameter variations, compare the performance of different algorithms, and critically interpret obtained results in the context of electromagnetic field modeling and solving engineering and scientific research problems.			
Course outline				
Theoretical teaching	Introduction. Electromagnetic field theory: static, stationary, and dynamic fields. Mathematical concepts in optimization: Jacobian matrix, Hessian matrix, local and global function minima. Direct and inverse problems in electromagnetics. Objective function and formulation of inverse problems. Classification of optimization methods: deterministic methods, variable metric methods, stochastic methods, and evolutionary algorithms. Multi-objective optimization and the concept of Pareto optimality. Application of optimization algorithms to test functions and analysis of convergence. Comparison of methods in terms of computational time and sensitivity of optimization results to parameter variations. Solving inverse problems in applied electromagnetics.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	A. Tarantola, „Inverse problem theory and methods for model parameter estimation“, Society for Industrial and Applied Mathematics – SIAM, 2005.			
2	N. V. Korovkin, V. L. Chechurin, M. Hayakawa, „Inverse problems in electric circuits and electromagnetics“, Springer, 2007.			
3	Z. Michalewicz, „Genetic Algorithms + Data Structures = Evolution Programs“, Springer, 1995.			
4	D. E. Goldberg, „Genetic algorithms in search, optimization and machine learning“, Addison-Wesley Publishing Company. Inc., 1989.			
5	Z. Michalewicz, D.B. Fogel, „How to Solve It: Modern Heuristics“, Springer, 2004.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentoring work; Seminar papers			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		40
Colloquia				
Projects	60			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Bounday Element Method in Electromagnetics		
Lecturer (for lectures)		Raičević B. Nebojša, Vučković N. Ana		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The objective of the course is to deepen theoretical and methodological knowledge in the field of boundary element methods in electromagnetics, as well as to enable students to independently model, analyze, and critically evaluate electromagnetic systems using modern numerical and software tools.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently model and analyze electromagnetic systems using boundary element methods and hybrid boundary element methods, formulate and discretize appropriate integral models, perform numerical simulations of 2D and 3D problems, critically assess the accuracy and stability of obtained solutions, compare different numerical approaches, and interpret results in the context of complex electromagnetic problems.			
Course outline				
Theoretical teaching	Fundamentals of Numerical Methods. Boundary Element Method (BEM): Formulation of integral equations, discretization using boundary elements, modeling of sources within the analysis domain, linear and quadratic elements. Examples. Hybrid Boundary Element Method: Theoretical framework, system modeling, analysis of 2D and 3D problems. Examples. Modern Software Tools: Contemporary software tools for electromagnetic field analysis based on the application of the boundary element method.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	M. Sadiku, „Numerical techniques in Electromagnetics“, CRC Press, 2001.			
2	D. Poljak, C. A. Brebbia, "Boundary Element Methods for Electrical Engineers", WIT Press, 2005.			
3	C. A. Brebbia, J. Dominguej, "Boundary Element Methods, An Introduction Course", McGraw Hill, 1989			
4	D. Poljak, “Advanced Modeling in Computational Electromagnetic Compatibility”, Wiley & Sons, 2007.			
5	N. B. Raičević, S. R. Aleksić, "One method for electric field determination in the vicinity of infinitely thin electrode shells", Engineering Analysis with Boundary Elements, ELSEVIER, Vol. 34, Issue (No.) 2, pp. 97-104, 2010.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Mentoring work; Seminar papers			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	40
Colloquia				
Projects		60		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Metrology of Electrical Quantities		
Lecturer (for lectures)		Denić B. Dragan, Simić M. Milan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Establishing knowledge in theoretical, legal and applied metrology and developing the ability to take a critical scientific approach in research and development of project tasks in the field of metrological quality assurance of electrical and electronic products, the ability to follow current literature in these areas and present technical ideas and innovations to the scientific public.			
Course outcomes	Complete understanding of scientific methods in the development and presentation of new solutions and contributions to the development of materialization and reproduction of measures and measurement methods, with achieved results in the scientific and professional public through published scientific papers.			
Course outline				
Theoretical teaching	Measurement and metrology. Development of measurement unit systems. Physical constants. National and international metrological institutions. Measurements and measurement methods. Analysis of sources of errors and interference in measurement. Metrological characteristics of measuring instruments. Calibration and comparison of measurement standards - traceability. Methods of processing measurement results and determining measurement uncertainty. Application of computer components in metrology for collecting, processing and presenting measurement information data.			
Practical teaching (exercises, OFE, study and research work)	Systematization of relevant scientific publications, analysis of selected chapters, preparation of seminar papers, participation in the implementation of project tasks and preparation of scientific papers for publication at conferences and in journals. Critical analysis of scientific results and development of new methods and solutions.			
Textbooks/references				
1	J. G. Webster, "Measurement, Instrumentation and Sensors Handbook", CRC Press, 2014.			
2	S. Tumanski, "Principles of Electrical Measurements", Taylor & Francis Group, 2006.			
3	P. Sydenham, "Handbook of Measurement Science", John Wiley & Sons, Ltd., 1982			
4	International professional journals: Metrology, Instrumentation and Measurement, Measurement Science and Technology, Measurement Science Review, etc.			
5	Professional publications of international metrological organizations and institutions.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures (theoretical teaching) with graphic presentation of material in the form of slides. Daily consultations of students with the subject teacher. Independent scientific research work of students in the form of writing seminar papers, implementing project tasks, as well as preparing scientific papers for publication at conferences and in journals.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	0	Written exam		30
Exercises	0	Oral exam		30
Colloquia	0			
Projects	40			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Sensors and Measurement Transducers		
Lecturer (for lectures)		Denić B. Dragan, Dinčić R. Milan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	To provide students with knowledge in the field of sensors and measurement transducers, along with their various applications. The course also aims to introduce students to the principles of measuring non-electrical quantities and to sensor technologies used in modern measurement systems.			
Course outcomes	The student's ability to understand the operating principles of a wide range of sensors and measuring transducers. The ability to select an appropriate sensor and measurement method, and to implement a measurement system in practical applications involving the measurement of non-electrical quantities.			
Course outline				
Theoretical teaching	Basic definitions and block diagram of a measurement transducer. The sensor as the fundamental element of a transducer. Information-energy parameters of a transducer. Trends in the development of sensors and transducers. Active and passive transducers. Analog and digital transducers. Integrated and intelligent sensors and measurement modules. Temperature, force, pressure, flow, level, displacement, and humidity sensors. Analog electronic circuits for sensor interfacing.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Ambarish Paul, Mitradip Bhattacharjee, Ravinder Dahiya, "Solid-State Sensors", IEEE Press, Wiley Blackwell, 2024.			
2	Ekbert Hering, Gert Schönfelder, "Sensors in Science and Technology: Functionality and Application Areas", Springer, 2022.			
3	Walter Lang, "Sensors and Measurement Systems", River Publishers, 2021.			
4	Nathan Ida, "Sensors, Actuators, and Their Interfaces: A multidisciplinary introduction", The Institution of Engineering and Technology, 2020.			
5	Patrick F. Dunn, "Fundamentals of Sensors for Engineering and Science", CRC Press, 2019.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures and laboratory work conducted within the framework of a study-research project. The aim is to familiarize students with scientific research and actively involve them in the process of writing and presenting scientific papers.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Systems for Measurement and Control		
Lecturer (for lectures)		Dinčić R. Milan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	To provide students with knowledge in the field of sensors and measurement transducers, along with their various applications. The course also aims to introduce students to the principles of measuring non-electrical quantities and to sensor technologies used in modern measurement systems.			
Course outcomes	The student's ability to understand the operating principles of a wide range of sensors and measuring transducers. The ability to select an appropriate sensor and measurement method, and to implement a measurement system in practical applications involving the measurement of non-electrical quantities.			
Course outline				
Theoretical teaching	Basic definitions and block diagram of a measurement transducer. The sensor as the fundamental element of a transducer. Information-energy parameters of a transducer. Trends in the development of sensors and transducers. Active and passive transducers. Analog and digital transducers. Integrated and intelligent sensors and measurement modules. Temperature, force, pressure, flow, level, displacement, and humidity sensors. Analog electronic circuits for sensor interfacing.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Ambarish Paul, Mitradip Bhattacharjee, Ravinder Dahiya, "Solid-State Sensors", IEEE Press, Wiley Blackwell, 2024.			
2	Ekbert Hering, Gert Schönfelder, "Sensors in Science and Technology: Functionality and Application Areas", Springer, 2022.			
3	Walter Lang, "Sensors and Measurement Systems", River Publishers, 2021.			
4	Nathan Ida, "Sensors, Actuators, and Their Interfaces: A multidisciplinary introduction", The Institution of Engineering and Technology, 2020.			
5	Patrick F. Dunn, "Fundamentals of Sensors for Engineering and Science", CRC Press, 2019.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures and laboratory work conducted within the framework of a study-research project. The aim is to familiarize students with scientific research and actively involve them in the process of writing and presenting scientific papers.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Measurement and Acquisition Systems		
Lecturer (for lectures)		Živanović B. Dragan, Denić B. Dragan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Establishing the necessary knowledge for the development and application of measurement-acquisition systems based on information technologies and microcomputer components. Evaluating the impact of applied techniques on measurement accuracy.			
Course outcomes	Mastering scientific methods in the development and presentation of new solutions for measurement-acquisition systems. Acquiring specific techniques for the development and application of these systems, as well as assessing accuracy and other characteristics essential for the practical application of selected or developed components.			
Course outline				
Theoretical teaching	Connecting sensors, measurement transducers, and actuators. Signal conditioning (linearization, amplification, filtering, etc.). Acquisition of measurement-information data (multiplexing, S&H circuits, converters). Modern analog-to-digital converters, testing of converter characteristics. Standard interfaces and protocols. Intelligent measurement transducers. Electrical isolation in measurement systems. Virtual instrumentation and virtual laboratories. Examples of practical implementations. Real-time operation. Software design. Automated test systems based on DAQ and applications.			
Practical teaching (exercises, OFE, study and research work)	Development of project tasks and design of specific devices and measuring systems. Theoretical analysis of measurement errors depending on the characteristics of sensors and measuring transducers. Analysis of the impact of signal conditioning. Consideration and experimental verification of circuit protection against electromagnetic interference. Implementation of various measurement error reduction techniques and comparison with existing intelligent measuring transducers and sensors.			
Textbooks/references				
1	J. Park, S. Mackay, "Practical data acquisition for instrumentation and control systems", Elsevier. 2003.			
2	„Data acquisition handbook“, Measurement Computing Corporation 2012.			
3	Burns, M.,Roberts,G.W.,"Mixed-Signal IC Test and Measurement", Oxford Univ. Press,New York, 2012.			
4	S. Sumathi, P. SurekhaLabVIEW Based Advanced Instrumentation Systems. Springer, 2007.			
5	S. Tumanski „ Principles of Electrical Measurement“, Taylor&Francis, 2006.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is carried out through lectures, consultations, systematization of relevant publications, computer simulations and/or experimental research, independent student research work, and publication of papers in conferences and journals.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	20	Written exam		
Exercises		Oral exam		40
Colloquia				
Projects	40			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Process Measurement Technique		
Lecturer (for lectures)		Jovanović R. Jelena		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The goal of the course is to acquire advanced knowledge of modern measurement methods and the integration of measurement systems in industrial processes. Throughout the course, the functionality of sensors and measuring devices in real industrial environments will be analyzed, as well as the application of IoT technologies, digital communication protocols and Edge AI systems for industrial monitoring and optimization.			
Course outcomes	Upon completion of the course, the student will be able to: critically analyze contemporary scientific and technical approaches in the field of process measurement and industrial instrumentation; independently select, design, and integrate advanced sensor and measurement-information systems into complex industrial processes; develop and apply new methodologies to improve the accuracy, reliability, and intelligence of measurement systems; apply modern industrial communication protocols, IoT architectures, and Edge AI algorithms for smart measurement, data analysis, and predictive maintenance; plan and conduct experimental research, analyze and critically interpret the obtained results using appropriate scientific methods; independently prepare, present, and publish research results in the field of process measurement technology.			
Course outline				
Theoretical teaching	Industrial sensors for position, displacement, angle, vibration, acceleration, force, torque, strain, pressure, differential pressure, temperature, flow and level; Gas analysis, humidity measurement and chemical analysis; Digital measurement systems; Digital sensors and signal processing; Industrial communication protocols; Wireless sensor networks in industry; IoT and Industry 5.0 in industrial measurements; Smart sensors and automatic process control; IoT sensors in smart factories; Application of Edge AI in predictive maintenance and process optimization; Integration of IoT platforms with PLC and SCADA systems; Calibration and verification of sensors; Wireless communications in industrial measurement systems; Measurement uncertainty analysis in industrial applications; Measurement systems in process industry; Case studies.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	P. Raj, B. Sundaravadivazhagan, A. S. Raja, M. M. Alani, "Edge AI for Industry 5.0 and Healthcare 5.0 Applications", CRC Press, 2025.			
2	D. Gupta, V. H. C. de Albuquerque, A. Khanna, P. L. Mehta, "Smart Sensors for Industrial Internet of Things: Challenges, Solutions and Applications", Springer, 2021.			
3	G. R. Kanagachidambaresan, B. N,"Sensors and Protocols for Industry 4.0: Industrial Applications of Maker Tech", Apress, 2023.			
4	B. K. Mishra, S. Mallik, D.-N. Le, "Smart Sensors for Industry 4.0: Fundamentals, Fabrication and IIoT Applications", Wiley-Scrivener, 2024.			
5	R. Anandan, S. Gopalakrishnan, S. Pal, N. Zaman,"Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance", Wiley-Scrivener, 2022.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0

Teaching methods	Teaching is carried out through lectures, analysis and discussion of contemporary scientific publications, case studies, and the development of research assignments. Within the course, students apply methods of critical analysis of scientific results, compare different approaches to the design and integration of industrial measurement systems, define research problems, and propose possible innovative solutions. Research activities include the selection of appropriate experimental methods, planning of measurements, collection and processing of experimental data, analysis of accuracy, reliability, and measurement uncertainty of systems, as well as interpretation of the obtained results. As an outcome of these activities, students are expected to develop the ability to independently formulate research conclusions and prepare scientific and professional reports and presentations.			
	Grade (maximum number of points 100)			
	Pre-exam duties	Points	Final exam	Points
	Activity during lectures		Written exam	50
	Exercises		Oral exam	
	Colloquia			
	Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Virtual Instrumentation		
Lecturer (for lectures)		Živanović B. Dragan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Detailed introduction to measurement techniques and methods and processing of measurement results by using of virtual instrumentation. Study of the performance of individual components applied in measurement-information systems.		
Course outcomes		Complete mastery of scientific methods in the development and presentation of new solutions and contributions in the development of virtual instrumentation software for measurement-information applications.		
Course outline				
Theoretical teaching		Hardware structure of virtual instruments. Types of acquisition modules, characteristics. LabVIEW programming language – concept and advanced techniques. Working in real-time. Data flow and parallel execution of code segments. Signal analysis. Hardware and software techniques for compensating measurement results. Control of programmable instrumentation. Virtual laboratories. Calibration of computer-based measurement devices and systems. Automated test systems. Connection of sensor and actuator. Examples of practical applications of virtual instrumentation for working in real-time.		
Practical teaching (exercises, OFE, study and research work)		Development of project tasks and design of specific virtual instruments, development of data acquisition software, implementation of signal processing, communication with external instruments, real-time analysis of the achieved performance, and calculation and verification of the achieved virtual instrument specifications.		
Textbooks/references				
1		J. Conway, “A Software Engineering Approach to LabVIEW“, Prentice Hall, 2003.		
2		N. Kehtarnavaz, N. Kim, “Digital Signal Processing System-Level Design Using LabVIEW“, Newnes, 2005.		
3		J. Park, S. Mackay, “Practical data acquisition for instrumentation and control systems“, Elsevier. 2003.		
4		„Data acquisition handbook“, Measurement Computing Corporation 2012.		
5		S. Sumathi, P. SurekhaLabVIEW Based Advanced Instrumentation Systems. Springer, 2007.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is carried out through lectures, consultations, analysis of scientific literature, computer simulations and/or experimental research, development of seminar papers, independent student research work, and preparation of papers for publication in conferences and journals.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	20	Written exam		
Exercises		Oral exam		40
Colloquia				
Projects	40			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Industrial Measurement and Information Systems		
Lecturer (for lectures)		Denić B. Dragan, Jovanović R. Jelena		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The course aims to familiarize students with modern industrial measurement and information systems, providing both theoretical and practical knowledge required to analyze and design such systems. The course also aims to equip students for scientific research in this field.			
Course outcomes	Upon completion of the course, the student will be able to: critically analyze the architecture, functionality, and performance of modern industrial measurement-information systems; independently analyze and select appropriate hardware and software components for the implementation of complex measurement systems; design, implement, and improve virtual instruments and computer-based measurement systems; apply modern methods of signal processing, communication, and integration of measurement systems in industrial environments; independently conduct research, critically analyze scientific results, and propose new technical solutions in the field of industrial measurement-information systems; present the results of scientific research in the form of scientific and professional publications.			
Course outline				
Theoretical teaching	Basic block diagram of a measurement-information system. Definitions. Signal processing and signal transmission. Wired and wireless telemetry. Standards. Design of analog electronic circuits for sensor interfacing. Methods and systems for improving the signal-to-noise ratio. Computer-based systems and standard communication interfaces. Distributed measurement systems and Internet connectivity. Virtual instrumentation and virtual laboratories.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	A. W. Koch, "Measurement and Sensor Systems: A Comprehensive Guide to Principles, Practical Issues and Applications", Springer, 2023.			
2	J. Vedral, "Industrial and Laboratory Measuring Systems: Sensors, Distributed, Modular and Wireless Systems", River Publishers, 2024.			
3	S. Mekid, "Metrology and Instrumentation: Practical Applications for Engineering and Manufacturing", John Wiley & Sons, 2021.			
4	S. Chokkadi, R. Bandyopadhyay, "Smart Sensors Measurement and Instrumentation: Select Proceedings of CISCON 2021", Springer, 2023.			
5	D. K. Aswal, S. Yadav, T. Takatsuji, P. Rachakonda, H. Kumar, "Handbook of Metrology and Applications", Springer, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching is conducted through interactive lectures, analysis of modern industrial measurement-information systems, and critical consideration of current scientific achievements in this field. As part of their research work, students independently define and solve research tasks by applying methods of modeling, simulation, design, and experimental verification of measurement-information systems. Research activities include critical analysis and comparison of obtained results with relevant scientific publications, assessment of the advantages and limitations of existing solutions, as well as the formulation and evaluation of new approaches and technical solutions. Research results are presented through the preparation of scientifically grounded reports, oral presentations, and materials for scientific and professional publications.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	

Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Measurement and Information Technologies		
Lecturer (for lectures)		Denić B. Dragan, Dinčić R. Milan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Understanding the overall hardware-software architecture of the measurement information system, including its individual components. Comprehending how the applied measurement techniques affect measurement accuracy.			
Course outcomes	Ability to design measurement instruments as well as complete measurement systems, applying measurement information technologies. Ability to understand user requirements, select components, design individual assemblies, and analyze the achieved metrological parameters.			
Course outline				
Theoretical teaching	General models of the measurement process. Sources of measurement information and metrological parameters of measurement signals. Electronic circuits in the processing of measurement signals. Converters of analog measurement signals to digital code (multiplexers, samplers, ADC, DAC) and indicators. Architectures and hierarchical organization of software for measurement-acquisition systems. Universal acquisition cards. Measurement-information electronic modules (DAQ, DAS). Standard sensor interfaces. Intelligent and virtual measurement instruments. Principles of calibration of measurement modules and systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Dinesh K. Aswal, Sanjay Yadav, Toshiyuki Takatsuji, Prem Rachakonda, Harish Kumar, "Handbook of Metrology and Applications", Springer, 2023.			
2	Valery A. Slaev; Anna G. Chunovkina; Leonid A. Mironovsky, "Metrology and Theory of Measurement", De Gruyter, 2019.			
3	Alan S. Morris, Reza Langari, "Measurement and Instrumentation: Theory and Application", Third edition, ACADEMIC PRESS, 2020.			
4	Ivan E. Morse, Francis S. Tse, "Measurement and instrumentation in engineering: principles and basic laboratory experiments", CRC Press, 2018.			
5	Manabendra Bhuyan, "Intelligent Instrumentation: Principles and Applications", CRC Press, 2010.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Laboratory work conducted within the framework of academic research activities. Engagement in defined project assignments. Participation in the preparation and presentation of scientific papers.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Medical and Bioelectronic Measurement Technique		
Lecturer (for lectures)		Simić M. Milan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Systematization and acquisition of knowledge in the field of medical and bioelectronic measurement techniques.		
Course outcomes		Students' ability to design medical and bioelectronic measuring instrumentation, as well as to apply these specific measuring devices in practice.		
Course outline				
Theoretical teaching		Introduction to biomedical measurement instrumentation. Types and characteristics of biomedical measurement and acquisition systems, Sources of bioelectric potential. Biopotential amplifiers and signal processing. Electrical stimulation. EKG, EEG, EMG, ERG. Ultrasonic medical devices. Electrotherapy. Defibrillators. Pacemakers. Surgical instrumentation. Instruments for forming medical images based on electromagnetic radiation and based on nuclear magnetic resonance.		
Practical teaching (exercises, OFE, study and research work)		Systematization of relevant scientific publications in this field, analysis of selected chapters, preparation of a seminar paper and participation in the implementation of project tasks. From certain areas within the framework of defined project tasks, students are involved in the process of preparing papers for publication at conferences and in journals. Critical analysis of scientific results and development of new methods and solutions.		
Textbooks/references				
1		Joseph D. Bronzino (ed.), „Medical Devices and Human Engineering (The Biomedical Engineering Handbook, 4th Edition)“, CRC Press Taylor & Francis Group, 2015.		
2		A. Lay-Ekuakille, „Advances in Biomedical Sensing, Measurements, Instrumentation and Systems“, Springer, 2009.		
3		David Prutchi, Micahel Norris, “Design and Development of Medical Electronic Instrumentation”, JOHN WILEY & SONS, New Jersey, 2005.		
4		Joseph Carr, John Brown, “Introduction to Biomedical Equipment Technology”, Third Edition, PRENTICE HALL, New Jersey, 1998.		
5		John G. Webster, “Medical Instrumentation Application and Design, Second Edition”, JOHN WILEY & SONS, 1995.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures (theoretical classes) with graphic presentation of material in the form of slides. Daily consultations of students with the subject teacher. Independent scientific research work of students in the form of writing seminar papers, implementing project tasks, as well as preparing scientific papers for publication at conferences and in journals.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	0	Written exam		30
Exercises	0	Oral exam		30
Colloquia	0			
Projects	40			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Semiconductor Physics		
Lecturer (for lectures)		Prijić P. Aneta		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		The objectives of the course are focused on: - Refining knowledge in the field of crystal structure and quantum solid state physics; - Detailed analysis of the transport of carriers through semiconductors; - Consideration of non-equilibrium phenomena in the P-N and the metal-semiconductor junction; - Introduction to the charge sheet model of MOS structures; - Detailed analysis of C-V plots of MOS capacitors; - Study of the effects characteristic for the MOS transistors at a level of very large scale integration; - Getting acquainted with structures based on heterojunctions and semiconductor compounds; - In-depth consideration of the functioning of optoelectronic devices.		
Course outcomes		Learning outcomes allow a student to: - Explain the zonal theory in crystals from the aspect of the quantum-mechanical theory of a solid state; - Compare the classical relations for the transport of charge carriers in a semiconductor with particular solutions of the Boltzmann's kinetic equation; - Explain in detail the generation-recombination and diffusion processes in the semiconductors; - Highlight the specificity of the metal-semiconductor junction and heterojunction; - Present the charge sheet model of MOS structures; - Determine the characteristics of the specified MOS capacitor on the basis of its C-V plot; - Analyze the effects of MOS transistors scaling at a level of very large scale integration; - Explain in-depth the functioning of optoelectronic devices.		
Course outline				
Theoretical teaching		Crystal structure and solid state theory. Quantum and statistical physics of a solid state. Boltzmann's kinetic equation. Semiconductor in thermal equilibrium. Excess carrier concentrations and transport of carriers. Generation-recombination mechanisms. Metal-semiconductor junction and P-N junction. Non-equilibrium phenomena in the P-N junction and transport equations. Models of carriers mobility. MOS structure. Charge sheet model and C-V plot. MOS transistors and short channel effects. Parasitic effects, hot carriers, high temperature effects. Bipolar devices. SiGe, HEMT and other heterojunction devices. Solar cells, photodetectors, LEDs and laser diodes.		
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	S. Sze, Y. Li, K. Ng, "Physics of Semiconductor Devices", 3rd ed., Wiley, 2021 - selected chapters.			
2	B.-L. Anderson, R. Anderson, "Fundamentals of Semiconductor Devices", 2nd ed., McGraw-Hill Education, 2018 - selected chapters.			
3	D. Neaman, "Semiconductor Physics and Devices", 4th ed., McGraw-Hill, 2011 - selected chapters.			
4	P. Phillips, "Advanced Solid State Physics", 2nd ed. Cambridge University Press, 2012 - selected chapters.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0

Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Inclusion in the teaching process at bachelor and master academic studies; Seminars and projects.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises	30	Oral exam	40
Colloquia			
Projects	30		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Microelectronics		
Lecturer (for lectures)		Prijic D. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The objectives of the course are such that the PhD student will: - Learn in detail about certain types of analog microelectronic circuits and their models; - Learn about certain types of digital microelectronic circuits and their models; - Be able to analyze and design electronic products that contain analog and digital microelectronic circuits.			
Course outcomes	Learning outcomes are defined so that a PhD student will: - Distinguish the areas of application of certain types of analog microelectronic circuits and describe their functioning, using the model of the appropriate level of complexity; - Distinguish the areas of application of certain types of digital microelectronic circuits and describe their functioning, using the model of the appropriate level of complexity; - Design an electronic product that contains analogue and digital microelectronic circuits, according to the given functional and technical specifications.			
Course outline				
Theoretical teaching	Analog microelectronic circuits in practice: General principles of design of analogue microelectronic circuits; Power supply in integrated circuits and active load; Design of circuits with operational amplifiers (CMOS, bipolar, BiCMOS, JFET); Differential and multistage amplifiers; Feedback and stability; The effects of nonideality; Active higher order filters; Oscillators and function generators; A / D converters. Digital microelectronic circuits in practice: Digital circuits in MOS technology; Sequential logic circuits; MOS memory, SRAM, DRAM, Flash; Data converters. Optional: Digital circuits in bipolar technology. ECL and modified ECL circuits. TTL circuits. Logical circuits with Schottky diodes. Digital circuits in BiCMOS technology.			
Practical teaching (exercises, OFE, study and research work)	Study research work in the field of analogue or digital microelectronic circuits, according to students affinity.			
Textbooks/references				
1	R. Jaeger, T. Blalock, „Microelectronic Circuit Design”, 5th. Edition, McGraw-Hill, 2016 (Selected chapters).			
2	B. Razavi, "Design of Analog Integrated Circuits", 2nd ed., McGraw-Hill, 2015 (Selected chapters).			
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Consultation. Participation in research projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Nanotechnology and Nanodevices		
Lecturer (for lectures)		Aleksić M. Sanja		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering advanced knowledge in the field of nanotechnology and nanocomponents.			
Course outcomes	Extended theoretical knowledge in the field of nanotechnology and nanocomponents, as well as the applications of systems based on these components. The student is expected to understand fundamental principles and be open to acquiring new knowledge.			
Course outline				
Theoretical teaching	Materials for nanocomponents. Dielectric and ferroelectric materials (electronic properties and quantum effects), magnetoelectronic materials (magnetism and magnetotransport in layered structures), organic molecules (electronic structure, properties, and reactions), neurons (molecular structure and electrical excitation). Technological processes and methods for thin film analysis. Characterization of nanostructures. Geometrical characterization. Characterization of layers and surfaces. Functional characterization. Nanosensors and nanoactuators. Nanocomponents. Contacts and nanowires, quantum dots, nanodiodes, nanotransistors, nanoswitches. Nano-optical components. Logical nanocomponents and RAM memories. Data storage components. Hard disks, magneto-optical disks. Nanosystems and their applications.			
Practical teaching (exercises, OFE, study and research work)	Simulations and modeling of nanostructures (using computer tools such as Silvaco Atlas or Sentaurus TCAD): simulation of quantum confinement in nanowires or quantum dots, design of MOSFETs in the nanometer scale and analysis of scaling effects, comparison of classical and quantum transport models in components, simulation of nanostructured solar cells (e.g., silicon nanowire or perovskite cells).			
Textbooks/references				
	1	Cao, G., & Wang, Y. (2011). Nanostructures and Nanomaterials: Synthesis, Properties and Applications (2nd ed.). Springer. ISBN: 9789814322508		
	2	Poole, C. P., Jr., & Owens, F. J. (2003). Introduction to Nanotechnology. Wiley-Interscience. ISBN: 9780471079354		
	3	Waser, R. (Ed.). (2012). Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices (3rd ed.). Wiley-VCH. ISBN: 9783527409273		
	4	Cao, G. (2004). Nanostructures & Devices: Integrated and Scalable Synthesis and Fabrication. Springer. ISBN: 9780387233307		
	5	Internal scripts and lectures by the instructors are available on the course website.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Specialized advanced lectures conducted in small groups or individually, with an emphasis on the latest research and publications. Research seminars where doctoral students present their research and participate in discussions. Mentorship, where each student is assigned a mentor and potentially a co-mentor from industry or another institution. Independent work on projects and publications. Publishing scientific papers in domestic and international journals. Participation in conferences and involvement in domestic and international projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises	20	Oral exam		50
Colloquia				
Projects	30			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Materials Science		
Lecturer (for lectures)		Paunović V. Vesna		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring academic knowledge in the field of materials, the ability to connect knowledge from different fields. Getting acquainted with the most modern achievements in the research of new materials and their applications. Studying the structure-properties-application relationships.			
Course outcomes	The learning outcome enables the student to: •Independently or as part of a multidisciplinary team, solve complex scientific, development, and technological problems in the field of materials science. •Plan, organize, and manage scientific research work in accordance with modern scientific methodologies. •Efficiently participate in the preparation and implementation of international scientific research projects. •Apply international standards and ethical principles when conducting project activities and presenting scientific results.			
Course outline				
Theoretical teaching	Matter and materials. Correlation of synthesis-structure-properties-application of materials. Structural properties of materials. Crystallography. Advanced methods of material characterization. Energy and defects of the crystal lattice. Modeling and simulation of new materials. Phase diagrams and design of new materials. Models of the electronic structure of materials. Electrical conductivity in metals. Semiconductor materials and their properties. Optical properties of semiconductors. Electronic ceramic materials. Liquid crystals. Ferroelectrics. Ferrites. Nanopowders, nanomaterials, and nanotechnologies of material synthesis.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	W. D. Callister, D.G.Rethwisch, Materials Science and Engineering, John Wiley & Sons Inc, 2014			
2	S. O. Kasap, Principles of Electronic Materials and Devices, McGraw-Hill, 2018			
3	M.X.Keshavarz, T.M.Klapötke The Properties of Energetic Materials, De Gruyter Graduate, 2018			
4	Wei Gao, Zhengwei Li, Nigel M Sammes, Introduction to electronic materials for engineers, (2nd edition) World Scientific Publishing Company, 2016			
5	James F. Shackelford, Introduction to Materials Science for Engineers, Pearson, 2015			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations, laboratory and practical exercises			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Optoelectronics		
Lecturer (for lectures)		Paunović V. Vesna		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering advanced theoretical and practical principles of operation of light sources and detectors, as well as methods of analysis and design of optoelectronic circuits and systems.			
Course outcomes	The learning outcome enables the student to: •Explain and apply advanced theoretical knowledge from the fields of optics and radiation physics when analyzing optoelectronic phenomena. •Design and implement optoelectronic components and systems using modern practical techniques and technologies. •Analyze the operating principles, internal structure, and technical characteristics of various types of laser devices and systems. •Configure, control, and safely manage laser systems within diverse industrial and scientific applications. •Independently or as part of a team, develop a professional engineering project that includes the integration and control of laser and optoelectronic devices.			
Course outline				
Theoretical teaching	Optoelectronics as experimental sciences. Optics, electrodynamics, electronics, quantum and statistical physics of radiation. Source of light and components of telecommunication devices and systems. Interaction of radiation and matter. Laser oscillation. Semiconductor lasers. Telecommunication laser systems. Information displays, LCD, TFT LED, and OLED displays. Discrete and integrated optoelectronic components and devices. Integrated optoelectronics as a combination of classical electronics, optics, microelectronics, and quantum electronics. Integrated optical devices as transmitters, modulators, demodulators, and switching elements. Limits and perspective of the development of optoelectronics.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	B. Naci, E. Ayse, Semiconductors for Optoelectronics : Basics and Applications, Springer International Publishing, 2019			
2	S.C.Gupta, Optoelectronic devices and systems , Prentice Hall of India Private, 2015			
3	John Dakin, Robert Brown, Handbook of optoelectronics- Applied Optical Electronics,CRC press, 2022			
4	Anil K. Maini Lasers and Optoelectronics, John Wiley and Sons Ltd, 2013			
5	J.A. Hernández-Cordero,M. Hautefeuille, Field guide to optoelectronics and photonics , SPIE press 2021			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Theoretical lectures, consultations, participation in realization of scientific-research projects, seminar papers and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program			Electrical Engineering and Computer Science	
Type and level of studies			Doctoral Studies	
The name of the course			Semiconductor Devices	
Lecturer (for lectures)			Danković M. Danijel	
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Detailed analysis of physical phenomena in semiconductors and semiconductor devices. Study of the specific applications of semiconductor devices in electronic circuits.		
Course outcomes		Learning outcomes are defined so that the student will have detailed knowledge of the semiconductor devices and their applications in the different electronic circuits.		
Course outline				
Theoretical teaching		Heavy Doping Effects in Semiconductors. Transport of Carriers. I-h junctions. The effective surface recombination velocity. Diode. Silicon Bipolar Junction Transistors. Heterojunction Bipolar Transistors. Modeling of Bipolar Junction Transistors. Metal-Semiconductor based Devices. Schottky Barriers and Ohmic Contacts. Field Effect Transistors based on Semiconductor Compounds. GaAs MESFET's. Heterostructure Field Effect Transistors (HFETs). MOSFETs. CMOS/BiCMOS. SOI and 3D structures. Low-voltage and Low-power Devices. Power Devices. Power Bipolar Junction Transistors. Power VDMOS transistors. IGBT. Devices Based on SiC.		
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	James M. Fiore, "Semiconductor Devices: Theory and Application", Mohawk Valley Community College-Utica, 2019.		
	2	Massimo Rudan, Rossella Brunetti, Susanna Reggiani, "Springer Handbook of Semiconductor Devices", Springer, 2023, ISBN: 978-3-030-79826-0.		
	3	Adrian Kitai, "Fundamentals of Semiconductor Materials and Devices", Wiley, 2023, ISBN: 978-1-119-89142-0.		
	4	Simon M. Sze, Ming-Kwei Lee, "Semiconductor Devices - Physics and Technology", 3rd Edition, John Wiley & Sons, 2012.		
	5	Simon M. Sze, Kwok K. Ng, "Physics of Semiconductor Devices", 3rd Edition, Wiley Interscience, 2007, ISBN 978-0-471-14323-9		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Theoretical teaching, active role in the scientific-research projects, seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Power Devices and Circuits		
Lecturer (for lectures)		Manić Đ. Ivica, Marjanović B. Miloš		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering detailed knowledge of the structure, manufacturing technology, operating principles, characteristics, and applications of electronic components and power circuits.			
Course outcomes	Possessing theoretical and practical knowledge for the proper understanding of circuit functions and the selection of appropriate power components for various applications and reliable operation of electronic circuits.			
Course outline				
Theoretical teaching	Types and Applications of Power Components. Structures and Technologies: bipolar, CMOS, BiCMOS, SOI. Discrete Components: PN, PiN, Schottky diodes. Thyristors: SCR, GTO, triac, optically triggered thyristor. Power Bipolar Transistor, Darlington Pair. Static Induction Components: SIT, SiTh. MOS Components: DMOS, VDMOS, MOS-controlled thyristor. IGBT. Electrical Characteristics and Effects: high current densities, quasi-saturation, on-resistance, thermal effects, secondary breakdown, parasitic structures. SOA (Safe Operating Area) region. SPICE Models. Power Integrated Circuits: integration principles, power modules, hybrid and monolithic ICs. High-Voltage and Intelligent Power Circuits (ICs), SoC. On-Chip Component Isolation. Functional Blocks of ICs: power block, driver, references, communication, protection (voltage, current, temperature). Applications: ICs in automobiles, lighting control, electric motor operation.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Muhammad H. Rashid, Power Electronics Handbook, Butterworth-Heinemann, 2024.			
2	Hubert Henry Ward, Mastering Analog Electronics : Unlocking the Power of Circuits and Semiconductors, Apress, 2024.			
3	Muhammad H. Rashid, SPICE and LTspice for Power Electronics and Electric Power, CRC Press, 2024.			
4	Daniel W. Hart, Power Electronics, McGraw-Hill, 2011.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Theoretical lectures. Independent student work through homework assignments. Consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures		10	Written exam	25
Exercises			Oral exam	25
Colloquia				
Projects		40		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Microsensors		
Lecturer (for lectures)		Vračar M. Ljubomir, Pejović M. Milić		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring a higher-level knowledge for understanding and practical application of microsensors and microsystems.			
Course outcomes	Upon successful completion of this doctoral course, the student will be able to critically analyze and scientifically evaluate contemporary achievements in the field of microsensors, independently formulate and implement innovative research solutions through advanced multiphysics modeling, design, and optimization of new structures, as well as experimentally verify original scientific results and publish them in leading international journals.			
Course outline				
Theoretical teaching	Information-processing systems. Measurement and control systems. Actuators. Sensor definitions and classification. General sensor characteristics and limitations. Parameters definition. Sensor calibration methods. Error corrections. Fabrication technology. Reliability issues. Sensors for radiation, mechanical, thermal ,magnetic , chemical and biological signals. Sensors design and operation. Applications. Smart integrated sensors and actuators. Functional blocks. Micro-electro-mechanical sensors (MEMS), technology, components and systems. Integrated sensors and MEMS components.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	J.W. Gardner, Microsensors: Principles and Applications, Wiley, UK, 1994			
2	Gardner J., Varadan V., Awadelkarim O.: Microsensors, MEMS and smart devices: technology, applications & devices , Wiley, UK (2001)			
3	MEMS Inertial Device, MDPI Books, Basel, Switzerland, 2024. [Online]. Available: https://www.mdpi.com/books/reprint/8872-mems-inertial-device			
4	W. Wang R. Yang, Eds., Design and Fabrication of Micro/Nano Sensors and Actuators, MDPI Books, Basel, 2024. https://www.mdpi.com/books/reprint/9567-design-and-fabrication-of-micro-nano-sensors-and-actuators			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Auditorial teaching, student tutorials			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	10	Written exam		
Exercises		Oral exam		60
Colloquia				
Projects	30			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Reliability of Electronic Devices and Microsystems		
Lecturer (for lectures)		Davidović S. Vojkan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The aim of the course is to master knowledge in the field of reliability (reliability function, time to failure, operating time between failures, distribution functions: exponential, Weibull, normal, gamma distribution), master knowledge in physics and failure diagnostics of various components that make up microsystems (semiconductor components, printed circuit boards, capacitors, coils, batteries, transceivers), as well as acquire the knowledge necessary for forming microsystem reliability models and using software tools in modeling. The course also aims to introduce students to existing standards and laboratory methods for accelerated testing (HALT, HASS, BURN-IN, thermal cycling, centrifugation), and to calculate the reliability of microsystems based on specific tests conducted on individual components.			
Course outcomes	The student possesses knowledge of basic reliability theory, understands the reliability function and failure intensity, and understands several different distribution functions to the extent that he can mathematically successfully process them, i.e. perform the necessary calculations. He knows the possible forms and causes of failures in the constituent elements of microsystems, knows the mechanisms and models for accelerating failures under the influence of elevated temperature, voltage, moisture, radiation, electrostatic discharge, vibration, mechanical and simultaneous stress. He possesses the necessary knowledge about tests for certain components, laboratory equipment for their implementation. He is familiar with modern scientific achievements in the field and relevant scientific publications. Qualified to use a microscope with a Leitz camera, measure dimensions, program and use a Binder 56 chamber. He knows how to form a microsystem reliability model, use software tools and perform reliability calculations.			
Course outline				
Theoretical teaching	Failure mode, failure mechanism and cause, reliability function, failure intensity, bath-tub curve, time to failure, operating time between failures, distribution functions (exp, Weibull, Gauss, gamma). Substrate defects, oxide defects, dielectric breakdown, contact and metallization failures, housing and lead quality, failures due to overstress (temperature, humidity, electric field, ionizing radiation, ESD, mechanical stress and vibration). Reliability of printed circuit boards, capacitors, coils, Li-ion batteries, transceiver modules, MEMS components, solar modules. Failure diagnostics, microscopy and electrical testing. Accelerated reliability testing - tests and laboratory equipment, models for acceleration factor. MIL-STD and IEC standards. Lifetime analysis and reliability modeling.			
Practical teaching (exercises, OFE, study and research work)	EXERCISES: Classic tasks based on practical examples, calculation of distribution function, time to failure, reliability. LABORATORY WORK: Accelerated testing of several components (elements of microsystems) under harsh conditions (temperature, polarization or radiation). Analysis of results and modeling. CONSULTATIONS: Processing of results and analysis of scientific publications.			
Textbooks/references				
1 F. Jensen, Electronic Component Reliability, John Wiley, 1995				
2 J. W. McPherson, Reliability Physics and Engineering (Time-To-Failure Modeling), Springer, 2010, ISBN 978-1-4419-6347-5				
3 Elsayed A. Elsayed, Reliability Engineering (2nd edition), John Willey & Sons, 2012, ISBN 978-1-118-13719-2				
4 Lawrence M. Leemis, RELIABILITY - Probabilistic Models and Statistical Methods,(2nd edition), 2009, ISBN 978-0-692-00027-4				
5 Microelectronics Reliability, Elsevier, selection of the latests papers from the field				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations, computational exercises and processing of tasks from practical examples, analysis of presentations and scientific publications, laboratory work, consultations in the form of mentorship in processing the results.			

Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures	20	Written exam	20
Exercises	20	Oral exam	20
Colloquia	10		
Projects	10		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Prognosis of the Material Properties		
Lecturer (for lectures)		Paunović V. Vesna		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering the principles of material property prediction with special emphasis on designing and obtaining materials for electronics with predefined properties. Prognosis of the materials properties as the basis of developing and producing materials and nanomaterials.			
Course outcomes	The learning outcome enables the student to: •Apply the material properties prognosis diagram to link crystal structure to the specific requirements of the electronics industry. •Independently design a material with predefined physical, electrical, and structural properties for a specific application. •Integrate theoretical knowledge and practical skills to solve complex engineering tasks in the development of new functional materials. •Critically analyze and optimize the "structure-property-technology-application" chain to improve the efficiency of electronic systems.			
Course outline				
Theoretical teaching	Prognosis of material properties as a basis for obtaining materials with predetermined properties. Scientific chain of theory-experiment. Evolution of material structure and nanomaterials. Diagram structure-properties-technology from the standpoint of electronic devices and the prognosis of metal, ceramic, amorphous, and other materials. Micro and electronic structure as the basis for a modern prognosis of material properties. Thermodynamic methods of prognosis. A classical and statistical-thermodynamic approach to the study of thermal, mechanical, electromagnetic, galvanomagnetic, and electro-optical phenomena. The prognosis of the properties of materials from the standpoint requires micro, nano, opto, and low-temperature electronics. Perspectives of prognosis development with reference to modern technologies.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	S. O. Kasap, Principles of Electronic Materials and Devices, McGraw-Hill, 2018			
2	W.D.Callister, "Materials Science And Engineering an introduction, John Wiley&Sons Ltd, 2003			
3	W. D. Callister, D.G.Rethwisch, Materials Science and Engineering, John Wiley & Sons Inc, 2014			
4	K.M. Gupta Nishu Gupta, Advanced Electrical and Electronics Materials: Processes and Applications, John Wiley & Sons, 2015			
5	A.S.M.A. Haseeb Encyclopedia of Materials: Electronics, Elsevier, 2023			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Classical lectures, consultations, participation in realization of scientific-research projects, seminar papers and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Software Engineering in Microelectronics		
Lecturer (for lectures)		Pantić S. Dragan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Training students for research, development, and application of advanced software engineering methods in the design, modeling, simulation, and verification of microelectronic systems and components. Students will gain knowledge of the tools and techniques necessary for the implementation of reliable and optimized microelectronic solutions.		
Course outcomes		Upon completion of the course, the student will be able to: apply advanced software engineering methodologies in microelectronics, use tools for hardware description programming, simulation, and verification, develop their own methods for optimizing microelectronic systems, and research and analyze the latest trends and scientific papers in this field.		
Course outline				
Theoretical teaching		Introduction. Modeling and simulation. Application of computers and software tools in the design process of microelectronic components and systems. Design of numerical experiments (DOE). Simulation and modeling of technological processes for the production of microelectronic components. Modeling of ion implantation, diffusion, oxidation, etching, and lithographic processes. Simulation of electrical characteristics of components. System of basic semiconductor equations, mobility models, carrier generation and recombination. Simulation domain, discretization, and solving of partial differential equation systems. TCAD software tools. Electrical modeling. Models of passive and active components. Parameter extraction. Analytical, physical, numerical, and neural modeling approaches. Model verification and calibration. Structural modeling. 2D and 3D structures. Simulation of thermal and mechanical stress effects.		
Practical teaching (exercises, OFE, study and research work)		Through exercises, independent projects (seminar papers), and computer-assisted lab work, the student is trained to independently use commercial software tools for the design and simulation of technological processes and electrical characteristics of various semiconductor components.		
Textbooks/references				
	1	Plummer, J. D., Deal, M. D., & Griffin, P. B. (2000). Silicon VLSI Technology: Fundamentals, Practice and Modeling. Prentice Hall. ISBN: 9780130850375		
	2	Sze, S. M., & Ng, K. K. (2006). Physics of Semiconductor Devices (3rd ed.). Wiley-Interscience. ISBN: 9780471143239		
	3	Selberherr, S. (1984). Analysis and Simulation of Semiconductor Devices. Springer-Verlag. ISBN: 9783211824672		
	4	Pantić, D., Pešić, T., & Jovanović, E. (2020). Modeling and Simulation in Microelectronics. University of Niš, Faculty of Electronic Engineering. ISBN: 9788680321346		
	5	Internal scripts and lectures by the instructors are available on the course website.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Specialized lectures in small groups or individually, with an emphasis on the latest research and publications. Research seminars where doctoral students present their work and participate in discussions. Mentorship activities, with each student assigned a mentor and potentially a co-mentor from industry or other institutions. Independent work on projects and publications. Publishing scientific papers in domestic and international journals. Participation in conferences and involvement in domestic and international projects.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises		20	Oral exam	50
Colloquia				
Projects		30		



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Solar Systems, Technologies and Devices		
Lecturer (for lectures)		Pantić S. Dragan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The aim of the course is to equip doctoral students with the ability to independently conduct research and develop advanced technologies and components in the field of solar energy, with a special focus on the integration, optimization, modeling, and performance analysis of photovoltaic (PV) and thermal solar systems.			
Course outcomes	Upon completion of the course, the student will be able to: critically analyze and apply modern technologies in solar energy, design and optimize components of solar energy systems, apply advanced modeling and simulation methods (MATLAB, ANSYS, PVsyst, TRNSYS), develop their own methods for integration and control of solar systems, independently conduct research and publish scientific papers in relevant databases.			
Course outline				
Theoretical teaching	Introduction to the course and overview of solar energy. Physical fundamentals and spectral analysis of radiation. Solar cells. Current-voltage characteristics. High-efficiency solar cells. Structures and manufacturing processes. Modeling and simulation of solar cells using TCAD software tools. Photovoltaic modules and models. Solar thermal and photovoltaic systems. MPPT techniques and power converters. Energy storage and hybrid systems. Modeling and simulation of PV systems. Impact of climatic and geographic conditions. Exergy analysis of solar systems. Life cycle, LCA, and LCOE analysis. Integration into the power grid. Standards, measurement, and certification. Scientific research in solar energy. Presentation of seminar/research papers.			
Practical teaching (exercises, OFE, study and research work)	Application of satellite and local irradiance data. Data processing in MATLAB. Simulation of I–V and P–V characteristics of a PV cell. Temperature and spectral analysis of impacts on the PV cell. PV system simulation in PVsyst – basic model. MPPT algorithms in MATLAB/Simulink. PV + battery system modeling. Exergy analysis of the PV module. Energy and LCA analysis of the PV system. Dynamic system simulation in TRNSYS or Simulink. Performance comparison of different technologies. Simulation of grid connection. Bankability factor and standards analysis. Preparation of a seminar/research paper. Presentation of results and discussion.			
Textbooks/references				
1	Duffie, J. A., & Beckman, W. A. (2013). Solar Engineering of Thermal Processes (4th ed.). Wiley. ISBN: 9780470873663			
2	Messenger, R. A., & Ventre, J. (2010). Photovoltaic Systems Engineering (3rd ed.). CRC Press. ISBN: 9781439802861			
3	Khatib, T. (2013). Modeling of Photovoltaic Systems Using MATLAB: Simplified Green Codes. Wiley-IEEE Press. ISBN: 9781118649978			
4	Solar Components: Solved Problems and Exercises, S. Aleksić, A. Pantić, N. Stanojević, A. Petković, D. Pantić, Faculty of Electronic Engineering, 2023. ISBN: 978-86-6125-263-1			
5	Internal scripts and lectures by the instructors are available on the course website.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Advanced specialized lectures in small groups or individually, with a focus on the latest research and publications. Research seminars where doctoral candidates present their research and participate in discussions. Mentoring work, with each student assigned a mentor and potentially a co-mentor from industry or other institutions. Independent work on projects and publications. Publishing scientific papers in domestic and international journals. Participation in conferences and involvement in national and international projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises	20	Oral exam		50
Colloquia				
Projects	30			



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Technology, Design and Characterization of Microsystems		
Lecturer (for lectures)		Prijić D. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		The objectives of the course are such that a PhD student will: - Know the materials used in the production of microsystems; - Know the technological processes used for production; - Understand the process of designing and characterizing microsystems.		
Course outcomes		Learning specific learning outcomes are defined so that a PhD student will: - Distinguish materials used in the production of microsystems; - Distinguish, at the level of detail, technological processes and their order in the production of microsystems; - Explain, at the level of detail, the process of designing and characterizing microsystems; - Design the microsystem, according to the given functional and technical specifications.		
Course outline				
Theoretical teaching		Basic terms. Materials for microsystems - Materials in silicon technologies: monocrystalline silicon, polycrystalline silicon, silicon dioxide, silicon nitride, metal films, polymers. Materials in other technologies: silicon carbide, diamond, gallium arsenide and other III / V semiconductor compounds, piezoelectric ceramics. Material properties and physical effects. Technological processes in the production of microsystems - Standard technological processes: lithographic processes, thin layer deposition processes: CVD processes, PVD processes, Wet and dry etching. Other technological processes: anodic bonding, sol-gel deposition, electrolytic deposition. Technologies of Micro Machines. Surface micromachining, volume micromachining, LIGA, DXRL and EFAB technologies, assembling and integrating microsystems into enclosures. Flow diagram of microsystem design. Characterization of components and subsystems. Integration of analog and digital components of the microsystem. Microsystem power supply. Performance optimization.		
Practical teaching (exercises, OFE, study and research work)		Study research work in the field of materials, technological processes, design or characterization of microsystems, according to student affinity.		
Textbooks/references				
1		"MEMS: Fundamental Technology and Applications (Devices, Circuits, and Systems)", Ed. by V. Choudharu and K. Iniewski, CRC Press, 2013.		
2		Selected scientific papers (reviews)		
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Consultation. Research activities.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50

Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Reliability Modeling of MOS Devices		
Lecturer (for lectures)		Danković M. Danijel		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to basic accelerated testing for lifetime estimation in MOS transistors.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to estimate the lifetime of MOS devices under normal operating conditions.			
Course outline				
Theoretical teaching	Accelerated tests for lifetime estimation in MOS transistor. Methods of designing experiments. Bias temperature stressing of MOS transistor. The influence of bias temperature stressing on the electrical characteristics of the transistor. Modeling of electrical parameters of MOS transistors. Voltage (classical model based on linear extrapolation, VG model, 1/VG model, power-law model E-n) and temperature models for lifetime estimation of MOS transistors under normal operating conditions. Determination of the experimental lifetime values. Lifetime estimation - extrapolation to normal operating conditions. Analysis of the influence of the selection of the electrical parameter, the failure criteria, the range of selected voltages and temperatures, and the chosen model for lifetime estimation.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Amit Kumar, "Reliability Issues and Approaches in MOSFET circuits", Lambert Academic Publishing, 2020, ISBN: 978-6200325785.			
2	Souvik Mahapatra, „Recent Advances in PMOS Negative Bias Temperature Instability: Characterization and Modeling of Device Architecture, Material and Process Impact“, Springer Nature, 2021, ISBN 978-981-16-6119-8.			
3	Tibor Grasser, Editor, „Bias Temperature Instability for Devices and Circuits“, Springer, 2014, ISBN 978-1-4614-7909-3.			
4	J.W. McPherson, Editor, „Reliability Physics and Engineering – Time-To-Failure Modeling“, Springer, 2014, ISBN 978-1-4419-6348-2.			
5	M. Tahori, Editor, „Microelectronics Reliability, Special Section: Modelling the Negative Bias Temperature Instability“, Elsevier, 2018, ISSN 0026-2714.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Theoretical teaching, active role in the scientific-research projects, seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Influence of Radiation on Microelectronic Devices		
Lecturer (for lectures)		Ristić S. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Gaining knowledge about the types of radiation and their effects on microelectronic components.			
Course outcomes	Learning outcomes are defined so that the student, in addition to theoretical knowledge from this scientific area, will have the ability to distinct the effects of radiation, with special emphasis on the effects of gamma radiation in microelectronic devices and their annealing.			
Course outline				
Theoretical teaching	Properties of ionizing and neutron radiation. Generation, transport and trapping of electrons and holes in silicon dioxide. Trapping centers at the oxide-semiconductor interface induced by radiation. Effects of radiation on MOS components. Technology of components hardening on radiation. Effects of radiation induced by technological processes. Influence of radiation-induced defects on the characteristics of semiconductor components. Annealing of defects and recovery of semiconductor components after irradiation.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	J. Khan, Ed., „Radiation Effects of Advanced Electronic Devices and Circuits“, Basel, Switzerland: MDPI, Mar. 2024. doi: 10.3390/books978-3-7258-0432-0.			
2	K. Iniewski, Ed., „Advanced Materials for Radiation Detection“, Cham, Switzerland: Springer Nature Switzerland AG, Aug. 2021. doi: 10.1007/978-3-030-76461-6.			
3	R. Baumann and K. Kruckmeyer, „Radiation Handbook for Electronics: A Compendium of Radiation Effects Topics for Space, Industrial and Terrestrial Applications“, Rev. A. Dallas, TX, USA: Texas Instruments, 2019.			
4	Y. Q. de Aguiar, F. Wrobel, J.-L. Autran, and R. G. Alía, „Single-Event Effects, from Space to Accelerator Environments. Cham“, Switzerland: Springer International Publishing, 2024. doi: 10.1007/978-3-031-71723-9.			
5	T. P. Ma, Paul V. Dressendorfer, Ionizing Radiation Effects in MOS Devices and Circuits, Wiley. 1989.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consulting teaching; Participation in the realization of scientific-research projects; Seminars and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	60
Colloquia		40		
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electrical Machines and Energy Efficiency		
Lecturer (for lectures)		Stajić P. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Operating characteristics of electric machines. Application of electrical machines (pumping stations, compressor plants, fans, heating and cooling systems, transport systems, alternative energy sources, etc.). Efficiency of electrical machines during the life cycle. Energy-efficient electrical machines. European policy and programs for improving the energy efficiency of electric motor drives. Interdisciplinary approach to energy efficiency in industry. Efficiency measurements at the installation sites of electrical machines. Obstacles to increasing energy efficiency. Theoretical foundations and methodological approach to increasing the energy efficiency of systems. Energy efficiency management of systems: theory and examples of good practice.		
Course outcomes		Students will be capable to perform measurements and analyses at electrical machine installation sites to determine their energy efficiency. They will also be introduced to modern solutions for increasing energy efficiency that are applied in the most industrially developed countries and trained to select and practically implement optimization of electrical energy consumption in various systems.		
Course outline				
Theoretical teaching		Operating characteristics of electrical machines. Application of electrical machines (pumping stations, compressor plants, fans, heating and cooling systems, transport systems, etc.). Efficiency of electrical machines during the life cycle. Energy-efficient electrical machines. European policy and programs for improving the energy efficiency of electric motor drives. Interdisciplinary approach to energy efficiency in industry. Efficiency measurements at the installation sites of electrical machines. Obstacles to increasing energy efficiency. Theoretical foundations and methodological approach to increasing the energy efficiency of systems. Energy efficiency management in different systems: theory and examples of good practice.		
Practical teaching (exercises, OFE, study and research work)		Part of the course is conducted through mentoring and part through individual research and study work in the field of electrical machines and transformer. Through mentoring, students are introduced with the subject content. The study and research work is based on active study of primary scientific sources, analysis of the energy efficiency of systems with electrical machines and technical possibilities for its increase, conducting experiments at the locations of electrical machines, proposing and implementing measures to increase energy efficiency.		
Textbooks/references				
1		P. Tolander, J. Palm "Improving Energy Efficiency in Industrial Energy Systems", Springer-Verlag, London, 2013.		
2		A. Emadi, J.C. Andreas "Energy-Efficient Electric Motors", Marcel-Dekker, New York, 2005.		
3		F. Parasiliti, P. Bertoldi "Energy efficiency in motor driven systems", Springer-Verlag, Berlin, 2003.		
4		D. R. Wulfinghoff "Energy Efficiency Manual", Energy Institute Press, Maryland, U.S.A. 1999.		
5		A. de Almeida,P. Bertoldi, W. Leonhard "Energy Efficiency Improvements in Electric Motors and Drives", Springer-Verlag, Berlin Heidelberg, 1997.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Lectures via the presentation, discussions and consultations. Assistance in performing experiments and prepare students for independent research and scientific papers publishing.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electrical Drives - Selected Chapters		
Lecturer (for lectures)		Mitrović N. Nebojša, Petronijević P. Milutin		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Students are introduced to characteristic industrial applications of electric drives, methods of analysis, equipment integration, parameterization, commissioning, and supervision.			
Course outcomes	Students are capable of independently analyzing operation in steady-state and transient regimes, modeling mechanical couplings, designing control algorithms, and applying multimotor drive systems.			
Course outline				
Theoretical teaching	Introduction. Electrical drives as prime movers in industrial processes. Integration with higher-level control systems. Modeling of electrical drives. Control of electric drives. Power converter–motor–load systems. Multiquadrant operation. Parameter identification and estimation. Measurement of drive and process variables. AC motor drives. Coordinate transformation. Voltage- and current-fed converters. Induction motor drives: scalar and vector control methods. Implementation of modern control techniques. Influence of parameter detuning. Sensorless operation. Synchronous motor drives: control of synchronous machines, including scalar and vector control. High-power drive systems. Sensorless operation. Special-purpose AC machines and their applications in electric drives.			
Practical teaching (exercises, OFE, study and research work)	Part of the course is conducted through individual research and study in the field of electric motor drives. This work involves active engagement with primary scientific sources, numerical simulations, and the organization and execution of experiments.			
Textbooks/references				
1	Paul Krause, Oleg Wasynczuk, Scott Sudhoff, Steven Pekarek, "Analysis of Electric Machinery and Drive Systems", Institute of Electrical and Electronics Engineers, 2013.			
2	Piotr Wach, "Dynamics and Control of Electrical Drives", Springer, 2011.			
3	P. Vas, "Electrical machines and drives: a space vector approach", Clarendon press, Oxford, 1992.			
4	R. Krishnan, Electric Motor Drives, Virginia Tech, Prantice Hall 2001.			
5	W. Leonhard: "Control of Electrical Drives", Springer-Verlag Berlin, 1985.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching methods include lectures based on comprehensive presentations of essential literature, guided tutorials, and support during laboratory work. Independent study and research form a core component of the program.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	40
Colloquia				
Projects		60		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Diagnosis and Condition Monitoring of Electrical Machines		
Lecturer (for lectures)		Kostić Z. Vojkan, Mitrović N. Nebojša, Petronijević P. Milutin		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The study of modern methods for the diagnosis and monitoring of electrical machines in electric drives with and without power electronics converters. The study of conventional and advanced techniques of parameter estimation and states of electrical machines. The application and development of advanced methods for the analysis of electrical and non-electrical quantities.			
Course outcomes	At the end of the course, students will be able to independently analyze the operating conditions of electrical machines and evaluate the reliability of electrical drives based on the obtained results. Additionally, students will be capable of developing new methods for the analysis and estimation of electrical and non-electrical quantities of machines.			
Course outline				
Theoretical teaching	Electrical machine equations in stationary and general reference frames. Real-time signal processing. Methods for stator current spectrum analysis. Monitoring of stator and rotor fluxes. Rotor speed and position monitoring. Application of conventional techniques: encoders, tachometers, resolvers. Rotor slip and speed estimation based on electromagnetic torque. Torque and flux estimators. Frequency and speed estimation based on leakage flux measurement. Estimation in inverter-fed electric drives. Estimation of the drive inertia. Standstill response tests. Non-invasive methods. Thermovision testing of electrical machines. Diagnostic methods for eccentricity and broken rotor bars in induction motors. Vibration monitoring. Application of machine learning for identification and assessment of operating conditions of machines and drives.			
Practical teaching (exercises, OFE, study and research work)	Part of the course includes study and individual research work in the subject area. The scientific research involves the active study of relevant scientific sources, the implementation of computer simulations, and the use of modern equipment to conduct experiments aimed at solving specific problems and evaluating new scientific methods for diagnostics and preventive maintenance of machines.			
Textbooks/references				
1	Peter Vas; "Parameter Estimation, Condition Monitoring, and Diagnosis of Electrical Machines"; Oxford University Press; 1992.			
2	Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff; "Analysis of Electric Machinery and Drive Systems"; IEEE Press; 2002.			
3	Hamid A. Toliyat, Subhasis Nandi, Seungdeog Choi, Homayoun Meshgin-Kelk; "Electric Machines: Modeling, Condition Monitoring, and Fault Diagnosis"; CRC Press; 2013.			
4	Peter Tavner, Li Ran, Christopher Crabtree; "Condition Monitoring of Rotating Electrical Machines"; 3rd Edition; IET; 2020.			
5	Jawad Faiz, Vahid Ghorbanian, Gojko Joksimovic "Fault Diagnosis of Induction Motors"; IET Digital Library; 2017.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures includes PowerPoint presentations. Literature analysis. Discussions, research work. Preparation and presentation of scientific papers at conferences.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Distribution Systems		
Lecturer (for lectures)		Korunović M. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Studying of up to date distribution systems, balanced and unbalanced distribution networks, load flow calculation, calculation of faulty conditions, voltage regulation, the ways of power flow control and load management, and calculation of networks with distributed generation.			
Course outcomes	Students will be able to critically analyse the operation of various distribution systems. They will also develop the competencies necessary for the independent development of new mathematical methods for analysing the operating modes of modern distribution networks.			
Course outline				
Theoretical teaching	Concepts of European and American distribution networks, as representatives of all types of distribution networks. Unbalanced distribution networks and unbalanced operating conditions. Load flow calculation and calculation of faulty conditions of balanced and unbalanced distribution networks. Voltage regulation in distribution networks. The ways of power flow control and load control in distribution networks. Load flow calculation in steady state condition and short-circuit analysis in the networks with small generations.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	T. Gonen: "Electric Power Distribution Engineering, fourth edition", CRC Press, Taylor & Francis Group, Boca Raton, 2024.			
2	A. Keyhani, M. N. Marwali, M. Dai: "Integration of Green and Renewable Energy in Electric Power Systems", John Wiley & Sons, Hoboken, New Jersey, 2010.			
3	A. A. Sallam, O. P. Malik: "Electric Distribution Systems", second edition, IEEE Press, John Wiley & Sons, Hoboken, New Jersey, 2019.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teching includes the classic lectures and consultations. It comprehends the interactive work with students in different areas of modern distribution systems, related to the study of scientific literature, computer simulations and the work on seminar paper.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Planning and Operation of Power Networks		
Lecturer (for lectures)		Korunović M. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to the planning and operation of power network principles in deregulated environment. The emphasis is on the usage of moder optimization techniques for the maintenance planning and unit comitment for the participation in the spot market.			
Course outcomes	Students will be capable for the application of appropriate optimization techniques for the short-term and long-term planning of operation in power networks. In addition, they will be trained to develop new optimization techniques, assess the value of planned investments, and create innovative solutions to problems that may arise in the electricity balancing market.			
Course outline				
Theoretical teaching	Planning and operation in a deregulated market. Decision-making techniques in the restructured electricity sector using fuzzy logic. Short-term and long-term maintenance planning of generation units. Short-term and long-term maintenance planning of grids. Coordination between short-term and long-term planning. Transmission expansion planning under long-term uncertainties. Short-term planning of electricity prices and generator market share. Electricity balancing markets: challenges in regional integration and integration of flexibility from renewable energy sources, demand site management and energy storage systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	M. Shahidehpour, H. Yamin, Zuyi Li: "Market Operations in Electric Power Systems: Forecasting, Scheduling, and Risk Management", Wiley-IEEE Press, 2002.			
2	M. Shahidehpour, M. Marwali: "Maintenance scheduling in restructured power systems", Kluwer academic publishers, USA, 2000.			
3	A. Ghosh: "Modern Power System", IEEE Press, John Wiley & Sons, Hoboken, New Jersey, 2025.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teching includes the classic lectures and consultations. It comprehends the interactive work with students in different areas of modern electric power networks, related to the study of scientific literature, computer simulations and the work on seminar paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Grounding and Grounding Systems		
Lecturer (for lectures)		Cvetković N. Nenad, Tasić S. Dragan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Objective of the course is to deepen knowledge of the physical foundations, characteristics, and modeling of grounding and grounding systems, as well as to enable students to independently apply, analyze, and critically evaluate analytical and numerical methods in the calculation, design, and optimization of complex grounding systems under real power engineering and industrial conditions.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently model, analyze, and optimize complex grounding systems using analytical and numerical methods, formulate and solve appropriate mathematical models, compare different approaches, and interpret simulation and calculation results in order to address complex engineering and scientific research problems.			
Course outline				
Theoretical teaching	Stationary and quasi-stationary characteristics of grounding systems. Structure of the electromagnetic field and potential in the vicinity of the grounding in linear, isotropic, homogeneous and nonhomogeneous soil structure. Calculation of unknown current distribution, leakage currents and integral characteristics of different grounding systems: grounding impedance, touch and step voltages. Derivation of the system of integral equations for the analysis of EM characteristics of grounding systems. Approximate methods for solving systems of integral equations: method of moments, pointmatching method, average potential method, equivalent electrodes' method, the finite element method, the estimation method. Frequency characteristics of grounding systems. Overhead and cable lines as elements of grounding systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	E. D. Sunde, Earth Conduction Effects in Transmission Systems, Dover Publications, New York, 1968.			
2	Md. Abdus Salam, Quazi M. Rahman, Power Systems Grounding, Springer; Softcover reprint of the original 1st ed., 2016, ISBN-13: 978-9811091650.			
3	G. P. Bierals, Grounding Electrical Distribution Systems, River Publishers, 2024, ISBN: 9788770042840.			
4	J. He, R. Zeng, B. Zhang: Methodology and Technology for Power System Grounding, John Wiley & Sons Singapore Pte. Ltd. 2013, DOI:10.1002/9781118255001.			
5	A. P. Sakis Meliopoulos, Power System Grounding and Transients: An Introduction. Series: Electrical and Computer Engineering, CRC Press,1988.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching, consultations, research work			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Optimisation Methods in Power Engineering		
Lecturer (for lectures)		Tasić S. Dragan, Marinković D. Slađana, Javor L. Vesna		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The objective of the course is to prepare students to be independent in application of modern optimization methods and solving complex power system optimisation problems.			
Course outcomes	After finishing this course, students will be able to apply the modern optimization methods and to solve complex power system optimisation problems.			
Course outline				
Theoretical teaching	Significance of the power system optimization methods. Definition of the optimization problem. Linear programming. Simplex and dual simplex. Transport problem. Nonlinear programming. Gradient methods. Newton's methods. Quadratic programming. Complex optimisation problems. Dynamic, Geometric and Multi-objective programming and their application for solving power system problems. Heuristic and metaheuristic optimization methods. Typical static and dynamic optimization problems: optimal power flow, optimal planning problems, unit commitment problems, voltage-reactive power static and dynamic optimization problems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	J. A. Momoh, Electric Power System Application of Optimization, Marcel Dekker, New York, 2009.			
2	J. Radosavljevic, Metaheuristic Optimization in Power Engineering, 2nd Edition, IET 2024.			
3	Y.H. Song (Editor), Modern Optimization Techniques in Power Systems, Kluwer Academic Publishers, 1990.			
4	Kwang Y. Lee (Editor), Zita A. Vale (Editor), Applications of Modern Heuristic Optimization Methods in Power and Energy Systems, Wiley-IEEE Press, 2020.			
5	L. Ashok Kumar, K. Mohana Sundaram, Optimal Power Flow Using FACTS Devices: Soft Computing Techniques, CRC Press, 2020.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, Discussions, Research work.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in Electromagnetic Compatibility		
Lecturer (for lectures)		Javor L. Vesna		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	Electromagnetic Compatibility in Power Engineering			
Course objectives	Study of advanced topics in the field of electromagnetic compatibility: design of devices and systems, electrostatic discharges, lightning discharges, intentional electromagnetic interference and protection of data (electromagnetic signals) from detection.			
Course outcomes	Upon completion of this course, students will be able to design devices and systems in accordance with EMC requirements; to analyze electrostatic discharges; to detect intentional electromagnetic interference and to understand the techniques of use/misuse of EM signals.			
Course outline				
Theoretical teaching	Practical problems in electromagnetic compatibility (EMC) testing. Modeling the phenomenon of electrostatic discharge, compliance with the standards in this area, and EMC techniques. Testing EMC with the power supply network and measures to improve the electrical power quality. Electromagnetic interference as a consequence of lightning electromagnetic pulse (LEMP) and nuclear electromagnetic pulse (NEMP). Detection of unintentional electromagnetic signals and causing intentional interference (TEMPEST). Application of EMC techniques in the design of devices and systems. Modern equipment for testing in EMC laboratories.			
Practical teaching (exercises, OFE, study and research work)	Practical teaching is implemented through exercises on the computer and participation in device testing in the electromagnetic compatibility testing laboratory.			
Textbooks/references				
1	Ott H. W., "Electromagnetic compatibility engineering," John Wiley & Sons, 2009.			
2	Williams T., "Electromagnetic compatibility for product designers," Newnes, 2016.			
3	Keiser K., "Electromagnetic compatibility handbook," CRC Press, 2004.			
4	Rachidi F., Tkachenko S., "Electromagnetic field interaction with transmission lines", WIT Press, 2008.			
5	Paul C., "Introduction to Electromagnetic Compatibility", Wiley, 2006.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures and consultations. Verification of device compliance with EMC standards and activities in the EMC testing laboratory.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electrical Machines and Transforms - Selected Chapters		
Lecturer (for lectures)		Stajić P. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Main topic of this course is to introduce students with specific working modes of electrical machines and transformers but also with potential applications of the theory in solving various practical problems that arise during the exploitation.			
Course outcomes	Students will be capable to apply the theory of electrical machines and transformers to solve various practical problems that arise during the exploitation. Depending on the types of problems, students will be able to make the optimal choice of measuring equipment needed to determine the parameters of mathematical model of electrical machines. Also, students will be introduced with the techniques with which it is possible to see electric machines and transformers as “measuring device” with which different system parameters can be obtained.			
Course outline				
Theoretical teaching	Description of a number of specific problems arising during the exploitation of electrical machines and transformers in various industries. Analyses and choice of approach for problem solving. Problem formulation and selection of approaches for their solution. Optimal choice of measuring and testing equipment. Selecting the best mathematical models for a specific situation. Useful software that can help in analysis. Connection between theory and practice. Examples of good practices for using simpler and more complicated models, based on the available data and test results. Analysis of the obtained results. Observation of electrical machines and transformers as "measuring devices" whose behavior provides precise information on the operation of the plant (facilities) in which they work.			
Practical teaching (exercises, OFE, study and research work)	Part of the course is conducted through mentoring and part through individual research and study work in the field of electrical machines and transformers. Through mentoring, students become familiar with a larger number of examples of the effective application of theoretical knowledge in solving problems that arise in engineering practice. The study and research work is based on active study of primary scientific sources, on numerical simulations and organizing and carrying out experiments in service conditions of electrical machines and transformers.			
Textbooks/references				
1	P. C. Krause, O. Wasynczuk, S. Sudhoff, "Analysis of Electric Machinery and Drive Systems", IEEE Press 2002			
2	M. J. Heathcote, "J&P Transformer Book", Elsevier, Book Aid International, England, 2007.			
3	J. Hindmarsh, "Electrical Machines and their Applications", Faculty of U.M.I.S.T. England, 1984.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures via the presentation, discussions and consultations. Assistance in performing experiments and prepare students for independent research and writing scientific papers.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Electrical Machines and Power Converters for Renewable Energy Sources		
Lecturer (for lectures)		Petronijević P. Milutin, Mitrović N. Nebojša, Kostić Z. Vojkan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Study of the specifics of machines and converters for applications in the field of renewable energy sources. Study of advanced control techniques, analysis of the influence of power supply on the operation of converters. Analysis of the influence of the power grid on the operation of converters. Analysis of problems in the operation of microgrids and study of possible solutions.			
Course outcomes	At the end of the course, students will be able to independently analyze the operation of machines and converters for applications in distributed power sources. Ability to solve problems in the area of choosing the type of machine, topology and converter control methods.			
Course outline				
Theoretical teaching	Inverter topologies for connecting renewable energy sources (RES) to the power grid. Fixed and variable speed wind turbines - DFIG, back-to-back power inverters. Photovoltaic sources. DC converters. Optimization of inverter operating modes. Stationary and dynamic operating modes. Synchronization with the grid, regulation of power flows. Grid inverter regulators. Operation of converters in isolated microgrids. Coordination of converter operation. Influence of power supply on converter operation: harmonics, voltage dips, overvoltages, short circuits. Integration of RES into distribution networks.			
Practical teaching (exercises, OFE, study and research work)	Part of the course is conducted through individual research and scientific work in the field of electromechanical energy conversion with RES applications. Scientific research work is based on active study of available literature, numerical simulations and conducting experiments with laboratory models. Part of the course is conducted through individual research and scientific work in the field.			
Textbooks/references				
1	Fuch, E.F.; Masoum, M.A.S."Power Conversion of Renewable Energy Systems," Springer, 2011.			
2	Remus Teodorescu, Marco Liserre, Pedro Rodríguez, "Grid Converters for Photovoltaic and Wind Power Systems," Wiley, 2011.			
3	Qing-Chang Zhong T. Hornik, "Control of power inverters in renewable energy and smart grid integration", Wiley, 2013.			
4	Huafeng Xiao, Mingming Li, "Advanced Control Techniques for Grid-Connected Inverters", Springer Nature Singapore, 2025.			
5	Qobad Shafiee, Mobin Naderi, Hassan Bevrani, "Microgrids: Dynamic Modeling, Stability and Control" Wiley-IEEE Press, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures using powerpoint presentations. Literature analysis. Discussions, research work.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Control of Electrical Drives and Power Converters		
Lecturer (for lectures)		Petronijević P. Milutin, Mitrović N. Nebojša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Study of modern methods of controlling converters and drives based on the application of digital signal processors. Study of conventional and advanced control techniques, analysis of the influence of power supply on the operation of converters and motors.			
Course outcomes	Students will be able to independently analyze and design advanced control methods for converters and drives with DC and AC motors. Ability to solve current problems in the field of control of modern converters and drives.			
Course outline				
Theoretical teaching	Control circuits for DC and AC drives. Pulse-width modulation (PWM) techniques - comparison of characteristics, selection. Space vector modulation. Optimization of converter control methods. Influence of power supply imperfections on converter and motor operation. Active line rectifiers. Operation of converters with asymmetrical power supply. Vector control of drives with asynchronous motors. Digital current (torque), speed and position controllers. Modern methods of controlling a synchronous motor with permanent magnets. Estimation of electrical and non-electrical quantities.			
Practical teaching (exercises, OFE, study and research work)	Part of the course is conducted through individual research and scientific work in the field of electromotor drives. Scientific research work is based on the active study of basic scientific sources, numerical simulations, organization and conduction of experiments with different types of converters and drives. Work in the laboratory using a DSP development environment and HIL devices for real-time simulations and development of control algorithms (C-HIL).			
Textbooks/references				
1	W. Leonhard, Control of electrical drives. 2001. doi: 10.1007/978-3-642-56649-3.			
2	F. Giri, AC Electric Motors Control. 2013. doi: 10.1002/9781118574263.			
3	S. N. Vukosavić, Digital control of electrical drives. 2007. doi: 10.1007/978-0-387-48598-0.			
4	Paul C. Krause, Oleg Wasynczuk, Scott D. Sudhoff, Steven D. Pekarek, "Analysis of Electric Machinery and Drive Systems, 4th Edition", Wiley-IEEE Press, 2025.			
5	A. Hughes, W. Drury, and B. C. in P. Drury, Electric motors and drives: Fundamentals, Types and Applications. Newnes, 2019.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures using powerpoint presentations. Literature analysis. Discussions, research work. Preparation of seminar papers and/or papers for scientific conferences.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Lightning Overvoltages Computation		
Lecturer (for lectures)		Javor L. Vesna		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	Lightning Protection			
Course objectives	Study of different models of the lightning electromagnetic field and the influence of the finite conductivity of the ground. Computation of lightning overvoltages on lines using modified telegraphers' equations.			
Course outcomes	Making a contribution to improving the model of the distribution of atmospheric overvoltages on power lines. Implementing computer subprograms for connecting with programs for the simulation of atmospheric overvoltages. Implementing a program for calculating the risk of atmospheric discharges in power plants, photovoltaic power plants, wind generators and wind farms.			
Course outline				
Theoretical teaching	Modeling the electromagnetic (EM) field of a lightning discharge. Modified telegraphers' equations and the influence of the external EM field. Taylor-Satterwhite-Harrison model. Agrawal-Price-Gurbaxani model. Rachidi model. Modeling losses and the influence of the finite conductivity of the ground. Baum-Liu-Tesche equations. Surge propagation on overhead and underground lines. Electrodynamic correction of equations of the classical line theory. Solving equations in the time domain by the finite difference method. Solving equations of EM wave propagation on lines in the frequency domain. Computer programs for simulating lightning surges in the electrical power system.			
Practical teaching (exercises, OFE, study and research work)	Practical teaching is implemented using computer programs for calculating the electromagnetic field of lightning discharges and surges in power systems.			
Textbooks/references				
1	Ametani A., "Numerical Analysis of Power System Transients and Dynamics," IET, 2015.			
2	Rachidi F., Tkachenko S., "Electromagnetic Field Interaction with Transmission Lines," WIT Press, 2008.			
3	Javor V., "Lightning electromagnetic field," (in both Serbian and English), Andrejević Endowment, Belgrade, 2011.			
4	Betz H.-D., Schmidt K., Oetttinger W.P, Wirz M., "Lightning: principles, instruments and application," Springer, Dordrecht, NL, 2008.			
5	Cooray V., "Lightning Protection," IET, 2010.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations and computer exercises.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program			Electrical Engineering and Computer Science		
Type and level of studies			Doctoral Studies		
The name of the course			Power Cable Engineering		
Lecturer (for lectures)			Tasić S. Dragan, Raičević B. Nebojša		
Lecturer/associate (for exercises)					
Lecturer/associate (for OFE)					
Number of ECTS		12	Course status (obligatory/elective)		Elective
Prerequisites	None				
Course objectives	The aim of the course is that students learn modern methods for the calculation of electrical and thermal fields in the cables, joints and cable terminations, cable ampacity in various service conditions and estimation of the lifetime of cables.				
Course outcomes	Upon completion of this course, students will be trained in understanding phzsics of the problem and solving the complex problems of construction and operation of electric power cables and cable accessories.				
Course outline					
Theoretical teaching	Finite element method. Equivalent electrode method. Boundary conditions for the electrical field calculation. Calculation of the electrical field in single and three-wire cables, joints and terminations. Boundary conditions for the calculation of thermal field. Calculation of thermal fields in single and three-wire cables, joints and terminations. Calculation of cable ampacity in working conditions. Aging of cables. Cable lifetime estimation. Calculation of ampacity with respect to cable aging.				
Practical teaching (exercises, OFE, study and research work)					
Textbooks/references					
1	W. A. Thue, Electrical Power Cable Engineering, CRC Press, 2017.				
2	G. J. Anders, Rating of Electric Power Cables in Unfavorable Thermal Environment, IEEE Pres, 2005				
3	A. B. J. Reece, T. W. Preston, Finite Element Methods in Electrical Power Engineering, Oxford University Press, 2000.				
4	S. K. Ganguli, V. Kohli, Power Cable Technology, CRC Press, 2018				
5	IEC 60287-Ed.2024, IEC 60853-Ed.2013, IEC 62095-Ed.2020.				
Number of classes of active education per week during semester/trimester/year					
Lectures	Exercises	OFE	Study and research work		Other classes
3	/	/	0		0
Teaching methods	Lectures, discussions and research work.				
Grade (maximum number of points 100)					
Pre-exam duties		Points	Final exam		Points
Activity during lectures			Written exam		
Exercises			Oral exam		50
Colloquia					
Projects		50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Power Quality in Distribution Networks		
Lecturer (for lectures)		Korunović M. Lidija		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The objective of the course is to introduce up to date problems of power quality in distribution networks to the students, and to habilitate them to apply contemporary scientific literature, valid standards, recommendations and other technical literature. Students should be habilitated to perform complex measurements of power quality indices in the laboratory and in the field.			
Course outcomes	Students will be habilitated to analyse and research wide range of power quality issues in up to date distribution networks, to apply and create standards, recommendations and other technical instructions, as well as to plan and to perform measurements of power quality indices in laboratory and in high voltage substations.			
Course outline				
Theoretical teaching	Importance of power quality for operation of distribution networks. Terms and definitions, importance and relevancy, tolerance limits. Methods of measurement and monitoring of power quality indices - advanced measuring systems. Voltage variations in steady state operating conditions and flicker - definitions, sources and effects. Voltage dips - definitions, characteristics, causes, propagation and effects. Sensitivity of the equipment on voltage dips and estimation of financial losses. Harmonics - definitions, sources and effects. Methods of the analysis of harmonics. Propagation of harmonics - calculation of the flows of harmonic currents. Methods of the elimination of harmonics. Design and calculation of filters. Overview of the international regulation and standards.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	R. Dugan, M. McGranaghan, S. Santoso, H. W. Beaty: "Electrical Power System Quality", second edition, McGraw-Hill Companies, 2004.			
2	596 CIGRE/CIRED JWG C4.112: "Guidelines for Power Quality Monitoring - Measurement Locations, Processing and Presentation of Data", Final Report, CIGRE, 2014.			
3	S. Padmanaban, C. Sharmela, J. B. Holm-Nielsen, P. Sivaraman: "Power Quality in Modern Power Systems", Elsevier, Academic Press, 2020.			
4	M. Rawa, Z. M. Ali, S. H. E. A. Aleem: "Power Quality and Harmonics Management in Modern Power Systems", IntechOpen, 2024.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching includes the classic lectures or consultations regarding different issues of power quality in distribution networks. The individual work with students includes the study of scientific sources, laboratory and field measurements, and the work on seminar paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Intelligent Adaptable Systems in Power Engineering		
Lecturer (for lectures)		Stajić P. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Main topic of this course is to introduce students with possibilities and importance of implementing intelligent adaptable systems in power engineering, hybrid analysis and modeling methods, and data-driven approach application techniques. Students will learn how to build and implement intelligent adaptable systems.			
Course outcomes	Students will be capable to apply hybrid analysis and modeling techniques, as well as to design and practically implement various intelligent adaptable systems that can be applied in various areas of the electric power industry. In addition to training for the application of various techniques of analysis and processing of existing data, experimentally recorded in real industrial plants or parts of power distribution networks, students will be trained to use modern measuring equipment and to record data in real power and industrial systems.			
Course outline				
Theoretical teaching	Overview of intelligent adaptable/adaptive systems (IAS). IAS architecture. Data-driven modeling approach. Hybrid analysis and modeling techniques. Data preprocessing and processing techniques. Visualization and observation of characteristic patterns necessary for IAS design. Description of a large number of specific problems that arise in the operation of various industrial systems. Problem setting and choice of approach to solve them. Selection of optimal hybrid models for given cases. Useful software that can make analysis easier. Connection between theory and practice. Design and implementation of new or additional functionalities in existing IAS. Verification of the operation of designed functions and/or systems in practice. Analysis and presentation of achieved effects.			
Practical teaching (exercises, OFE, study and research work)	Part of the course is conducted through mentoring with students, and part through individual research and study work in the areas of intelligent adaptable systems, hybrid analysis and modeling, with the application of the Data-Driven approach. Through mentoring, students are introduced to a greater number of examples of efficient and effective application of theoretical knowledge in solving problems that arise in engineering practice. Study and research work is based on the active study of basic scientific sources, the development of various hybrid models for appropriate adaptive control systems, numerical simulations and analyses using experimentally recorded data from real industrial plants and/or parts of electric power distribution networks.			
Textbooks/references				
1	M. Hou, S. Banbury, C. Burns, Intelligent Adaptive Systems - An Interaction-Centered Design Perspective, CRC Press, Taylor&Francis Group, 2015.			
2	B. R. Prusty, N. Gupta, K. Bingi, and R. Sehgal, Intelligent Data-Driven Modelling and Optimization in Power and Energy Applications, CRC Press, Taylor&Francis Group, 2024.			
3	B. Gabrys, K. Leiviska, J. Strackeljan, Do Smart Adaptive Systems Exist?, Springer-Verlag Berlin Heidelberg, 2005.			
4	D. Grimaldi, C. Carrasco-Farre, Implementing Data-Driven Strategies in Smart Cities - A Roadmap for Urban Transformation, Elsevier Inc. 2022.			
5	M. Fakhimi, N. Mustafee, Hybrid Modeling and Simulation - Conceptualizations, Methods and Applications, Springer, 2024.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures via the presentation, discussions and consultations. Assistance in performing experiments and prepare students for independent research and writing scientific papers.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Active Distribution Networks and Microgrids		
Lecturer (for lectures)		Petronijević P. Milutin		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Study of modern methods of controlling converters connected to the power grid. Study of the influence of the distribution network and consumers on the operating characteristics of distributed energy sources. Study of current problems related to the mass integration of renewable energy sources.			
Course outcomes	Students will be able to independently analyze and solve complex problems of integrating distributed energy sources into the power grid, taking into account specific energy management requirements, distribution network operating rules, and the specifics of grid-connected and isolated microgrids.			
Course outline				
Theoretical teaching	Typical configurations of grid-connected and isolated microgrids. Connection and dynamic interaction of the microgrid with the public distribution network. Technical and economic advantages of microgrids. Specifics of control in normal operating modes and during network failures. Hierarchical management of active distribution networks. Management of active and reactive power of distributed sources. SCADA and active distribution networks. Management of microgrids in island operation. Impact of distributed sources on power quality and reliability. Protection in islanded grid operation. Impact of microgrid on other energy resources. Virtual power plants. Integration of energy storage. Economics of microgrids and participation in the electricity market.			
Practical teaching (exercises, OFE, study and research work)	Part of the course is conducted through individual research and scientific work in the field of active distribution networks and microgrids. Scientific research work is based on active study of basic scientific sources, numerical simulations, real-time simulations and the use of hardware-in-the-loop (HIL) technologies. Organization and performance of experiments in the laboratory on microgrid models.			
Textbooks/references				
1	Guo, F., Wen, C., & Song, Y.-D. (2017). Distributed Control and Optimization Technologies in Smart Grid Systems (1st ed.). CRC Press.			
2	S. Chowdhury, S. P. Chowdhury, and P. Crossley, Microgrids and active distribution networks. IET, 2009.			
3	"Planning and Operation of Active Distribution Networks", Editors: Antonio Carlos Zambroni de Souza, Bala Venkatesh, Springer, 2022.			
4	"Microgrid architectures, control and protection methods", Editors: Naser Mahdavi Tabatabaei, Ersan Kabalci, Nicu Bizon, Springer, 2019.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures using powerpoint presentations. Literature analysis. Discussions, research work. Preparation of seminar papers and/or papers for scientific conferences.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Methodologies for Representation and Implementation of Future Computer Technologies		
Lecturer (for lectures)		Milentijević Z. Ivan, Ćirić M. Vladimir		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites				
Course objectives		To provide students with an in-depth understanding of current capabilities and limitations in computer technology, while exploring advanced techniques for enhancing the performance of hardware-software systems.		
Course outcomes		Students will master advanced hardware/software architecture representation methods and critically evaluate design trade-offs in system development.		
Course outline				
Theoretical teaching		Current development directions in computing aimed at overcoming limitations and pushing the boundaries of existing technologies. Fundamental characteristics of future computing technologies and design requirements. Advanced computer architectures. Representations that fully utilize the potential of new technologies. Formal representation methods in advanced computing technologies (IoT, dew, fog, cloud computing). Design methodologies. Novel approaches to optimization problems. DNA computing. Quantum computing.		
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	W. Stallings, Computer Organization and Architecture: Designing for Performance, 11th Ed. Pearson Education, 2022.			
2	D. Patterson and J. Hennessy, Computer organization and design: The Hardware/Software Interface, 6th Edition, MK, 2020.			
3	Misra, Sudip, Subhadeep Sarkar, and Subarna Chatterjee. Sensors, cloud, and fog: the enabling technologies for the Internet of Things. CRC Press, 2019.			
4	Buyya, Rajkumar, and Sukhpal Singh Gill, eds. Quantum Computing: Principles and Paradigms. Elsevier, 2025.			
5	A curated collection of selected accademic articles			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Consultations and guided research work		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program			Electrical Engineering and Computer Science	
Type and level of studies			Doctoral Studies	
The name of the course			Signals and Systems	
Lecturer (for lectures)			Janković S. Dragan, Radmanović M. Miloš	
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	The aim of the course is to improve students' knowledge in the field of signal and systems theory so that they will be able to define mathematical models of real physical systems and apply these models to describe the properties of the systems under consideration.			
Course outcomes	Students should acquire sufficient knowledge for practical applications of signal and system in the analysis, design and practical implementation of real systems.			
Course outline				
Theoretical teaching	Signals, systems and transformation, from theoretical mathematical foundations to practical implementation with circuit and program implemented algorithms. Methods of analysis signals and systems with applications in filtering, signal processing, communications, and process control. Convolution, spectral transformation algorithms for the calculation of the spectral transform, sampling methods, and discrete signal processing.			
Practical teaching (exercises, OFE, study and research work)	Independent research udner mentorship supervision and consutations.			
Textbooks/references				
	1	Oppenheim, A.V., Willsky, A.S., Signals & Systems, Prentice Hall, 1996.		
	2	B. Lathi, Linear Systems and Signal Processing, Librarian IECW, 2022.		
	3	R. Gopal, Problems and Solutions in Signals and Systems, CBS, 2011.		
	4	Fawwaz Ulaby, Andrew Yagle, Signals and Systems: Theory and Application, Michigan Publishing Service, 2018.		
	5	Vaidyanathan, P. P., Signals, Systems, and Signal Processing. Cambridge: Cambridge University Press, 2024.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, students work independently on projects, consultations			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in Software Engineering		
Lecturer (for lectures)		Rančić D. Dejan, Milosavljević Lj. Aleksandar		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Introduction to current research topics in the field of methods, tools and techniques for the development and evolution of software systems.			
Course outcomes	The student is competent to conduct original scientific research in the field of software engineering. They are able to critically evaluate existing software architectures and processes, as well as to develop and optimize new methods in the design of complex distributed, mobile, and intelligent software systems. The student is capable of formulating scientific hypotheses and publishing research results.			
Course outline				
Theoretical teaching	Advanced concepts in software modeling and analysis. Advanced concepts in software engineering (service-oriented architecture, model-driven architecture, agile software development). Component-based software development. Web services. Design and development of open source software. Multimedia information engineering. GIS application engineering. CIS application engineering. Web and distributed application engineering. Mobile services and systems engineering. Human-computer interaction from a software engineering perspective. Software maintenance and evolution.			
Practical teaching (exercises, OFE, study and research work)	Independent research work under mentorship. Application of Systematic Literature Review (SLR) and Design Science Research (DSR) methodologies. The student conducts a critical analysis of current scientific papers, identifies open research problems, proposes improvements to existing software processes or architectures, and performs empirical validation of the proposed solutions using relevant software quality metrics.			
Textbooks/references				
1	I. Sommerville, Software Engineering, 10th ed., Pearson Education Limited, 2016.			
2	R. Pressman, Software Engineering A Practitioner's Approach, 9th ed., McGraw-Hill, 2019.			
3	C. Jones, Software Development Patterns and Antipatterns, CRC Press, 2021.			
4	IEEE Transactions on Software Engineering, IEEE Computer Society, (selected scientific papers).			
5	Information and Software Technology, Elsevier, (selected scientific papers).			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations, study research work.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program			Electrical Engineering and Computer Science		
Type and level of studies			Doctoral Studies		
The name of the course			Advanced Topics in Data and Knowledge Engineering		
Lecturer (for lectures)			Stoimenov V. Leonid, Stojković R. Suzana, Stanimirović S. Aleksandar, Frtunić-Gligorijević B. Milena, Bogdanović D. Miloš		
Lecturer/associate (for exercises)					
Lecturer/associate (for OFE)					
Number of ECTS		12	Course status (obligatory/elective)		Elective
Prerequisites	None				
Course objectives	Provide students with insight into current research in the field of data and knowledge engineering, advanced database concepts and models, new database and knowledge base applications, information retrieval, information integration, e-systems, data and knowledge discovery processes, and the implementation of systems based on artificial intelligence.				
Course outcomes	Students will be able to recognize current problems in this field, and potential solutions. They will be able to apply some of the proposed methods and techniques and will be trained to critically approach their evaluation. Students will be trained to research in the domains of current theoretical topics.				
Course outline					
Theoretical teaching	Advanced concepts and models related to data engineering, including spatial, temporal, multimedia, distributed, and mobile databases. NoSQL databases and new concepts in data organization. Big data, properties, methods of collection, storage, and processing. Systems for analyzing big data. Social networks as data sources. Advanced concepts and models related to knowledge engineering. Information retrieval. Intelligent agents for searching data on the Web. Knowledge, knowledge representation, semantics, and ontologies. Large knowledge bases. Knowledge discovery process: spatial databases, multimedia databases, Web mining, knowledge discovery from text. New applications for databases and knowledge bases: document databases, Web and databases, e-business, e-government, e-learning, data warehouses, data mining. The role and place of computer vision, natural language processing, robotics, and other trends in the development of intelligent systems.				
Practical teaching (exercises, OFE, study and research work)	Design, development and implementation of data processing and analysis systems. Design, development and implementation of knowledge-based systems. Use of open source code for the implementation of data processing and knowledge systems.				
Textbooks/references					
1	R. Emasri, S. Navathe, Fundamentals of Database Systems, Pearson; 7 edition (2016), ISBN 10: 1292097612 ISBN 13: 9781292097619				
2	S. Russell, P. Norvig: Artificial Intelligence: A Modern Approach, 4th edition, Pearson, 2020. ISBN 978-0134610993.				
3	J.Han, M. Kamber, J. Pei, Data Mining: Concepts and Techniques, The Morgan Kaufmann Series in Data Management Systems, 3rd Edition, (2011), ISBN-10: 9780123814791, ISBN-13: 978-9380931913				
4	Erl, Khattak & Buhler, Big Data Fundamentals: Concepts, Drivers & Techniques (2016), Prentice Hall, ISBN-13: 9780134291079				
5	Handbook on Artificial Intelligence-Empowered Applied Software Engineering, Eds. Maria Virvou, George A. Tsihrintzis, Nikolaos G. Bourbakis, Lakhmi C. Jain, Springer Cham, 2023, ISBN 978-3-031-08204-7				
Number of classes of active education per week during semester/trimester/year					
Lectures	Exercises	OFE	Study and research work		Other classes
3	/	/	0		0
Teaching methods	Lectures, student presentations, homework assignments, and projects.				
Grade (maximum number of points 100)					
Pre-exam duties		Points	Final exam		Points
Activity during lectures			Written exam		
Exercises			Oral exam		50
Colloquia					
Projects		50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in Distributed Systems		
Lecturer (for lectures)		Stojanović H. Dragan, Stojanović M. Natalija, Janković S. Dragan, Stanimirović S. Aleksandar		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Mastering scientific, professional, and practical knowledge, as well as hardware and software concepts of modern distributed systems.			
Course outcomes	Upon successful completion of the course, the student is capable of critically analyzing, evaluating, and comparing modern architectures and models of distributed systems within a scientific and research context. The student develops the ability to independently identify open research problems in the field of distributed systems, including cloud, edge, and microservice-based architectures. The student is able to design and develop new methods, models, and algorithms for resource management, scalability, fault tolerance, and performance optimization in distributed systems. The student can independently apply and enhance advanced technologies and platforms for data processing, serverless computing, and event-driven systems as a foundation for original scientific research. The student is trained to present and critically interpret research results and to contribute to the development of innovative scientific solutions in the field of modern distributed systems.			
Course outline				
Theoretical teaching	Architectures of Distributed Computing Systems. Cluster computer systems and cloud computing. Programming models: shared memory model, message-passing model, peer-to-peer model, broker model. OpenMP. MPI. Architectures of cluster systems. Design requirements for clusters: performance, unified system image, fault tolerance, programming, load balancing, security, data storage. Application examples. Web services and service-oriented architectures (REST, SOA, gRPC, GraphQL, etc.). Microservices and microservice architecture. Microservice orchestration, monitoring, and adaptation. Serverless computing, Function as a Service (FaaS). Distributed systems for processing and analyzing large volumes and streams of data (Apache Hadoop, Spark, Flink, Kafka, etc.). Distributed data storage (Data Lake, Lakehouse). Distributed systems, platforms, and services on distributed infrastructure: edge, fog, and cloud. Resource management in distributed systems aimed at achieving adaptability, elasticity, and autonomy. Distributed systems based on artificial intelligence and machine learning.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	Maarten van Steen and Andrew S. Tanenbaum, Distributed Systems - 4th Edition, distributed-systems.net, 2025.		
	2	Jordi Torres, Supercomputing for Artificial Intelligence: Foundations, Architectures, and Scaling Deep Learning Workloads, https://torres.ai/supercomputing-for-ai/ , Independently published, 2025		
	3	Adi Polak, Scaling Machine Learning with Spark: Distributed ML with MLlib, TensorFlow, and PyTorch, O'Reilly Media, 2023		
	4	Simone Cirani, Gianluigi Ferrari, Marco Picone, Luca Veltri, Internet of Things: Architectures, Protocols and Standards, Wiley 2019.		
	5	Dan Marinescu, Cloud Computing: Theory and Practice, 3rd Edition, Morgan Kaufmann, 2022.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching methods: Lectures, independent student work on software projects, student seminars.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points

Activity during lectures		Written exam	
Exercises		Oral exam	40
Colloquia	40		
Projects	20		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Future Internet		
Lecturer (for lectures)		Tošić B. Milorad, Petković M. Ivan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introducing students to the European research agenda in the field of the Future Internet, as well as to research efforts on this topic in other parts of the world. Gaining experience with research topics and challenges relevant to currently active projects. Hands-on experience working with experiments on global development platforms for the Future Internet.			
Course outcomes	Students are capable of engaging in research work on any of the leading European projects in the field of the Future Internet. They are familiar with fundamental theories, enabling them to identify and solve problems in practice. They have acquired practical skills in experimentation and solution development.			
Course outline				
Theoretical teaching	General conceptual foundations of the Future Internet: overview of system architecture, the principle of network neutrality, socio-economic aspects, network perspective, security, resource management, quality of service, information objects, and business perspective. Cognitive systems. Services as core building blocks of the Future Internet: system architecture, peer-to-peer services, and service management. Virtualization. Overlay networks. Ontologies as structural elements of the Future Internet: reasoning and system management, analytics and performance measurement, resource logging and management. Fundamentals of the Future Internet: architectures, mobile Internet, cloud computing, identity and trust, search and discovery, experimentation. Future Internet architectures: fog computing and edge computing. Technological aspects: Internet of Things, networks, content, services. Applications: smart cities, smart energy management, smart healthcare, smart business systems, etc. Infrastructure and experimental approaches to development. Application development for integrated networks (6G+ architectures). Prototype implementation.			
Practical teaching (exercises, OFE, study and research work)	A research study paper with experimental results. Working towards publication of paper in a conference proceedings or a scientific journal.			
Textbooks/references				
1	Goransson, Paul, Chuck Black, and Timothy Culver. Software defined networks: a comprehensive approach. Morgan Kaufmann, 2016.			
2	Testbed network and computing environments for experimenting with the Internet of the future, available online (such as www.orbit-lab.org for example)			
3	Domingue, J. et. al., The Future Internet, Lecture Notes in Computer Science, Vol. 6656 2011, 465 p. ISBN 978-3-642-20897-3, Springer			
4	Correia, L.M.; Abramowicz, H.; Johnsson, M.; Wünstel, K., Architecture and Design for the Future Internet, 2011, 306 p. ISBN 978-90-481-9346-2, Springer			
5	Anand R Prasad, Future Internet Services and Service Architectures, River Publishers, 2011.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, student presentations, homework assignments, and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises	50	Oral exam		50
Colloquia				
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Design and Analysis of Parallel Algorithms		
Lecturer (for lectures)		Milovanović I. Emina		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	This course explores the principles and practise of parallel of parallel and distributed computing.			
Course outcomes	The student will have acquired the foundations necessary for conducting independent scientific research in the field of parallel processing. The student will be able to select appropriate problem decomposition techniques, assess the performance of parallel solutions, and design efficient algorithms for problems in linear algebra, numerical analysis, graph theory, and optimization. The student will develop the ability to apply parallel computing methods to complex computational problems and to critically evaluate scientific research results.			
Course outline				
Theoretical teaching	Principles of parallel algorithm design. Decomposition techniques. Data decomposition. Recursive decomposition. Speculative decomposition. Hybrid decomposition. Analyzing algorithms. Running time. Number of processors. Cost. Other measures. Parallel algorithms in linear algebra. Matrix-by-vector multiplication. Matrix-matrix multiplication. Solving systems of linear equations. Eigenvalue and eigen-vectors computation. Parallel methods in numerical analysis. Finding roots of polynomial. Integration. Interpolation. Orthogonal discrete transformations. Solving partial differential equations. Parallel algorithms in graph theory. Transitive closure and reduction. Paths in graph. Spanning trees. Tunnel problem. Min-cut max-flow. Greedy algorithms.			
Practical teaching (exercises, OFE, study and research work)	Individual research work: The analysis, design, and implementation of a parallel algorithm for a selected problem from the fields of linear algebra, numerical analysis, or graph theory. The research involves selecting an appropriate problem decomposition strategy, developing a parallel computing solution, conducting an experimental evaluation of its performance, and comparing the obtained results with sequential algorithms and approaches reported in relevant scientific literature.			
Textbooks/references				
1	Jorge Luis Ortega-Arjona, Patterns for Parallel Software Design, John Wiley & Sons, 2010.			
2	I. Foster, Designing and building parallel programs, Addison-Wesley, 1995.			
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, independent student work on projects, student seminars.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Bioinformatics		
Lecturer (for lectures)		Tošić B. Milorad, Nejković M. Valentina		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	For students to understand the role of information technologies in bioinformatics applications and to recognize the opportunities for professional and research careers in this field.			
Course outcomes	Ability to understand problems in the field of bioinformatics, to search for professional and scientific literature in this domain, knowledge of publicly available data sources, and adoption of the vocabulary and terminology specific to this field. Students are capable of developing software tools for accessing publicly available databases and manipulating the retrieved data. They are also able to design new algorithms and software solutions in the field of bioinformatics.			
Course outline				
Theoretical teaching	Selected current topics in bioinformatics. Basic concepts from natural sciences: genetics, proteomics, chemistry, biology. Exploration of domain knowledge: proteins, small molecules, reactions, etc. Selected algorithms used in bioinformatics software packages, application examples, current implementations, and the design of bioinformatics software. Bioinformatics software development: overview of existing publicly available data banks and software tools in this field. Software architectures for storing and managing protein-related data. Behavioral models. Interaction models. Software packages and algorithms for information retrieval and extraction in the bioinformatics domain. Use of data warehouses, databases, and ontologies in bioinformatics. Most commonly used programming languages in bioinformatics applications. Large language models for use in bioinformatics.			
Practical teaching (exercises, OFE, study and research work)	Study-based research work. Publication of one paper at a conference. Preparation of one paper for a journal.			
Textbooks/references				
1	Robinson, Peter N., and Sebastian Bauer. Introduction to bio-ontologies. Chapman and Hall/CRC, 2011.			
2	Kurgan, Lukasz, ed. Machine learning in bioinformatics of protein sequences: Algorithms, databases and resources for modern protein bioinformatics. World Scientific, 2022.			
3	Xiong, Jin. Essential bioinformatics. Cambridge University Press, 2006.			
4	Elkin, Peter L., ed. Terminology, ontology and their implementations. Springer, 2023.			
5	Mrozek, Dariusz. "Scalable big data analytics for protein bioinformatics." Computational Biology (2018).			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, student presentations, homework assignments, and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises	50	Oral exam		50
Colloquia				
Projects				

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Medical Informatics		
Lecturer (for lectures)		Janković S. Dragan, Milenković M. Aleksandar, Rajković J. Petar		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introducing students to the field of medical informatics and focusing on the reasons and the benefits of applying information and communication technologies along with corresponding statuses and perspectives.			
Course outcomes	The students should get the knowledge of the current state and future trends in medical informatics. They should develop the skills to critically examine benefits and disadvantages of applying different software solutions in medicine.			
Course outline				
Theoretical teaching	The definition of medical informatics. The importance and the role of medical informatics (quality, security, price, efficiency, research methods). Medical informatics and bioinformatics. Biomedical informatics. telemedicine. Medical information systems. Laboratory information systems. Clinical information systems. Telemedicine. Telediagnosics. The classes of information. Electronic patient record. Web based MIS. Interoperable MIS. Data and knowledge mining. Expert systems as a part of a MIS. Decision support systems. Data privacy and security. Medical data transfer standards. Medical imaging. DICOM. PACS. Data compression. Statistical data analysis. Data management and distribution. Data warehousing. Informational support for clinical researches.			
Practical teaching (exercises, OFE, study and research work)	The topics presented on the auditive and laboratory exercises follow material presented during lectures. The exercises are envisioned as a basis for the individual student projects development.			
Textbooks/references				
1	Shortliffe, Edward eds. Medical Informatics: Computer Applications in Health Care and Biomedicine. Reading, Springer Verlag 2003.			
2	Alfred Winter, Elske Ammenwerth, Reinhold Haux, Michael Marschollek, Health Information Systems, Springer, 2023.			
3	Bianca Steiner · Franziska Jahn, J.H. van Bommel, M.A. Musen, Handbook of medical Informatics, Springer Verlag, 1997.			
4	J.A. Magnuson, Brian E. Dixon, Public Health Informatics and Information Systems, Sprimnger Cham, 2020.			
5	Gashu, K.D., Mekonnen, Z.A., Chanyalew, M.A., Guadie, H.A. (eds) Public Health Informatics. Sustainable Development Goals Series. Springer, Cham, 2024.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, independent student work on projects, student seminars			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Applications of Spectral Techniques for Digital Devices Design		
Lecturer (for lectures)		Stojković R. Suzana, Radmanović M. Miloš		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Expose the necessary theoretical background for the consideration of spectral techniques and methods for the design of digital devices (software and hardware) using spectral techniques.			
Course outcomes	Students will be able to successfully and independently apply spectral methods in the analysis, design and testing of digital devices.			
Course outline				
Theoretical teaching	Mathematical fundaments for the consideration of spectral techniques in the design of digital devices. Spectral representations of discrete functions, functional development at the level of bits and words, and corresponding decision diagrams. Methods for efficient calculations of the spectral transformations, special emphasis on calculation by decision diagrams. Methods for calculation of autocorrelation functions and their application in this field. Analysis and synthesis of logic functions (binary and multiple-valued) by logic networks using spectral techniques. Spectral methods for the synthesis of sequential networks with emphasis on the problems of coding. Analysis autocorrection features and reliable design of digital systems using spectral techniques. Spectral methods for testing of digital systems.			
Practical teaching (exercises, OFE, study and research work)	A research work in the chousen field (spectral transform computation and/or application on hardware design, testing or verificatin) that includes: the systematic collection, analysis, and classification of relevant scientific literature; critical evaluation and improvement of existing methods or the development of a novel approach; experimental evaluation of the proposed solution; comparative analysis of the obtained results against relevant state-of-the-art methods; identification of limitations and open research questions, as well as the definition of directions for future research.			
Textbooks/references				
1	Karpovsky, M.G., Stankovic, R.S., Astola, J.T., Spectral Logic for Design of Digital Devices, Wiley, 2008.			
2	Radomir S. Stanković , Jaakko T. Astola , Claudio Moraga: Representations of Multiple-Valued Logic Functions, Springer, 2012.			
3	M. A. Thornton, R. Drechsler, D. M. Miller, Spectral Techniques in VLSI CAD, Kluwer Academic Publishers USA, 2012.			
4	R. Drechsler and D. Große, Eds., Recent Findings in Boolean Techniques, Springer, 2021.			
5	R. Drechsler and S. Huhn, Eds., Advanced Boolean Techniques, Springer, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Seminars, consultations			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in Mobile and Ubiquitous Computing		
Lecturer (for lectures)		Stojanović H. Dragan, Predić B. Bratislav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Mastering scientific, professional, and practical knowledge in the field of mobile and ubiquitous computing, with a particular focus on methods, technologies, and platforms for the development of mobile and ubiquitous systems, applications, and services.			
Course outcomes	Upon successful completion of the course, the student is capable of critically analyzing contemporary scientific approaches, architectures, and technologies in the field of mobile and ubiquitous computing. The student develops the ability to independently identify open research problems in mobile, IoT, and edge–fog–cloud systems, including context-aware and AIoT paradigms. The student is able to design and develop new methods for sensor data processing, mobile positioning, context management, and distributed data processing in ubiquitous systems. The student can independently develop and enhance models and solutions for security, privacy, interoperability, and scalability of mobile and IoT systems at a research contribution level. The student is trained to interpret, validate, and present scientific results, as well as to contribute to the development of innovative solutions in the field of mobile and ubiquitous computing.			
Course outline				
Theoretical teaching	Introduction to mobile and ubiquitous computing. Mobile and ubiquitous computing devices: smartphones, smart embedded devices, wearable computers, Internet of Things (IoT). Advanced wireless networks and wireless protocols. Methods and systems for collecting, processing, and analyzing data from sensors on mobile and IoT devices. Advanced technologies and systems for mobile positioning and location-based systems and applications. Context sensing and recognition in mobile and ubiquitous computing. Data management in mobile and ubiquitous computing and the Internet of Things. Architecture, design, and implementation of mobile and ubiquitous applications and services. Implementation of smart things and the application of artificial intelligence — AIoT. Development of IoT systems on edge infrastructure and implementation of edge intelligence. Development and deployment of IoT systems and services on cloud and edge-fog-cloud computing continuum. Implementation of ubiquitous IoT systems for big data processing and analysis. Human interaction with mobile computers and ubiquitous computing environments. Privacy and security in mobile and ubiquitous computing. Advanced systems, applications, and services: smart cities, homes, vehicles, healthcare, mobility and traffic, industry, agriculture, etc.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	A. King, Programming the Internet of Things: An Introduction to Building Integrated, Device-to-Cloud IoT Solutions, O'Reilly Media, 2021.			
2	Valentina E. Balas, Vijender Kumar Solanki, Raghvendra Kumar, Manju Khari, Internet of Things and Big Data Analytics for Smart Generation, Springer International Publishing, 2019			
3	Arun Sekar Rajasekaran, Fadi Al-Turjman, Suganyadevi S (Editors), AIoT: Artificial Intelligence of Things, Auerbach Publications, CRC Press, 2025			
4	Daniel Situnayake, Jenny Plunkett, AI at the Edge: Solving Real-World Problems with Embedded Machine Learning, O'Reilly Media, 2023			
5	Vijay Janapa Reddi, Machine Learning Systems, Volume 1 and 2, https://mlsysbook.ai/ , 2024-2026 Harvard University			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0

Teaching methods	Teaching methods: Lectures, independent student work on software projects, student seminars.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	40
Colloquia	40		
Projects	20		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science	
Type and level of studies		Doctoral Studies	
The name of the course		Advanced Topics in Computer Graphics	
Lecturer (for lectures)		Rančić D. Dejan, Milosavljević Lj. Aleksandar, Dimitrijević M. Aleksandar	
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS		12	Course status (obligatory/elective) Elective
Prerequisites	None		
Course objectives	Deepening students' knowledge in the field of computer graphics and introducing them to advanced techniques and algorithms, as well as current research in this field.		
Course outcomes	The student is able to independently analyze, compare, and critically evaluate contemporary methods, algorithms, and research results in the field of computer graphics. The student is able to identify open research problems, formulate research hypotheses, design and implement original or improved algorithmic solutions, and experimentally evaluate their accuracy, efficiency, and applicability. The student is qualified for independent scientific research, interpretation of the obtained results, and preparation of a scientific paper in the field of computer graphics.		
Course outline			
Theoretical teaching	Advanced rendering and animation techniques. Volume visualization. Modeling and visualization of natural phenomena. Fluid visualization (smoke, fire, liquid). Terrain modeling and visualization. Molecular graphics. Fractals and chaos. Advanced virtual reality techniques. Efficiency and complexity of graphics algorithms. Object-oriented graphics. Graphics and human perception. Organization and programming of graphics hardware.		
Practical teaching (exercises, OFE, study and research work)	Practical work includes the selection of a specific problem in the field of contemporary computer graphics, a systematic review and critical analysis of relevant scientific literature, the identification of limitations of existing methods, and the formulation of the objective of the practical work. In consultation with the instructor, the student designs and implements an algorithmic or system-level solution, defines the experimental procedure, selects appropriate metrics for evaluating accuracy, visual quality, efficiency, and computational complexity, compares the obtained results with existing approaches, and interprets the results. The final outcome of the practical work is technical documentation, an experimental report, and/or a research paper.		
Textbooks/references			
1	S. Marschner, P. Shirley, Fundamentals of Computer Graphics, 5th ed., CRC Press, 2021. ISBN: 978-0367505035		
2	M. Pharr, W. Jakob, G. Humphreys, Physically Based Rendering: From Theory to Implementation, 4th ed., MIT Press, 2023. ISBN: 978-0262048026		
3	A. Marrs, P. Shirley, I. Wald, Ray Tracing Gems II: Next Generation Real-Time Rendering with DXR, Vulkan, and OptiX, Apress, 2021. ISBN: 978-1484271858		
4	T. Akenine-Möller, E. Haines, N. Hoffman et al., Real-Time Rendering, 4th ed., CRC Press, 2018. ISBN: 978-1138627000		
5	Selection of current scientific papers from ACM Transactions on Graphics and from the SIGGRAPH, Eurographics, and IEEE VIS conferences, in accordance with the student's selected research topic.		
Number of classes of active education per week during semester/trimester/year			
Lectures	Exercises	OFE	Study and research work Other classes
3	/	/	0 0
Teaching methods	Lectures, consultations, analysis of scientific literature, development of a practical project, and preparation of a written report or a research paper.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topic in Intelligent Systems		
Lecturer (for lectures)		Stoimenov V. Leonid, Tošić B. Milorad, Stanimirović S. Aleksandar, Frtunić-Gligorijević B. Milena, Bogdanović D. Miloš		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	To provide students with insight into current research in the field of artificial intelligence and the implementation of intelligent systems. To present students with advanced techniques and methods of artificial intelligence, which can be used to implement modern distributed systems, new applications for knowledge bases, information retrieval, data and knowledge discovery processes, collaborative systems, etc.			
Course outcomes	Students will be able to recognize current problems in this field, and potential solutions. They will be able to apply some of the proposed methods and techniques and will be trained to critically approach their evaluation. Students will be trained to research in the domains of current theoretical topics.			
Course outline				
Theoretical teaching	Intelligent systems - overview and architecture. Artificial intelligence as a basis for the realization of intelligent systems. Software engineering for intelligent systems. Application of artificial intelligence in software engineering. Autonomous reasoning. Intelligent agents. Architectures that include perception, learning, knowledge representation, reasoning and reactions. Principles of machine learning. Combining different types of knowledge in agents (e.g., by use, probability-based reliability models, knowledge acquired through practice and knowledge management). Coordination and cooperation between agents. Machine learning and processing and analysis of existing data. Neural networks and deep learning. Interaction with intelligent systems: speech recognition and synthesis, computer vision. Knowledge representation - Ontologies and information semantics. Languages for representing ontologies. Ambient intelligence. General conceptual assumptions, strategy domain, business aspects, mathematical foundations, and some sociological foundations of intelligent information systems. Internet, social networks and artificial intelligence systems for processing and analyzing such data. Data analysis from systems for working with large amounts of data. Implementation of "smart" systems, integration with sensors and devices from the environment, Internet of Things and artificial intelligence.			
Practical teaching (exercises, OFE, study and research work)	Practical application and implementation possibilities of intelligent systems based on existing open source libraries and available data sources. Design and development of classical systems that include intelligent modules/systems.			
Textbooks/references				
1	S. Russell, P. Norvig: Artificial Intelligence: A Modern Approach, 4th edition, Pearson, 2020. ISBN 978-0134610993.			
2	J.Han, M. Kamber, J. Pei, Data Mining: Concepts and Techniques, The Morgan Kaufmann Series in Data Management Systems, 3rd Edition, (2011), ISBN-10: 9780123814791, ISBN-13: 978-9380931913			
3	Erl, Khattak & Buhler, Big Data Fundamentals: Concepts, Drivers & Techniques (2016), Prentice Hall, ISBN-13: 9780134291079			
4	G. Hulten, Building Intelligent Systems: A Guide to Machine Learning Engineering, 1st ed. edition (2018), ISBN-10: 1484234316, ISBN-13: 978-1484234310			
5	C. Sammut (Editor), G. I. Webb (Editor), Encyclopedia of Machine Learning and Data Mining, Springer, 2nd ed. (2017), ISBN-10: 148997685X, ISBN-13: 978-1489976857			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, student presentations, homework assignments, and projects.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points

Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in Specialized Information Systems		
Lecturer (for lectures)		Stojanović H. Dragan, Janković S. Dragan, Rančić D. Dejan, Predić B. Bratislav, Dimitrijević M. Aleksandar, Stanimirović S. Aleksandar		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Mastering scientific, professional, and practical knowledge in the field of specialized information systems, with a particular focus on methods, technologies, and platforms for the design and implementation of these systems.			
Course outcomes	Upon successful completion of the course, the student is capable of critically analyzing contemporary scientific approaches, architectures, and technologies in the field of specialized information systems. The student develops the ability to independently identify and formulate open research problems in various domains of specialized information systems, including distributed, mobile, event-driven, and big data systems. The student is able to design and develop new methods, models, and architectures based on service-oriented, middleware, and event-driven paradigms. The student can independently enhance existing solutions and develop innovative approaches for scalability, interoperability, reliability, and efficiency of domain-specific information systems. The student is trained to scientifically interpret, validate, and present research results, as well as to contribute to the development of new theoretical and practical solutions in the field of specialized information systems.			
Course outline				
Theoretical teaching	Special-purpose information systems and service-oriented architectures based on modern technologies. Distributed and peer-to-peer information systems. Mobile and ubiquitous information systems. Geographic, multimedia, medical, business, transportation, and intelligent information systems. Command and control information systems. Information systems based on the processing and analysis of large volumes of data. Information systems based on the publish-subscribe principle, event-driven systems, and event notification systems. Middleware for specialized information systems: message brokers, message-oriented middleware, transaction-oriented middleware and transaction management, application servers. Analysis, design, and implementation of specialized information systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Martin Kleppmann, Chris Riccomini, Designing Data-Intensive Applications, 2nd edition, O'Reilly Media, Inc., 2026			
2	Karen A. Wager, Frances W. Lee, John P. Glaser, Health Care Information Systems: A Practical approach for Health Care Management, John Wiley, Jossey-Bass; 2 edition,2009.			
3	Ian Kemp, C4I Systems Handbook, Issue 6, The Shephard Press Ltd, 2012.			
4	Adi Polak, Scaling Machine Learning with Spark: Distributed ML with MLlib, TensorFlow, and PyTorch, O'Reilly Media, 2023			
5	Vijay Janapa Reddi, Machine Learning Systems, Volume 1 and 2, https://mlsysbook.ai/ , 2024-2026 Harvard University			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching methods: Lectures, independent student work on software projects, student seminars.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		40
Colloquia	40			
Projects	20			



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Mathematical Fundament of the Game Theory		
Lecturer (for lectures)		Vučković V. Vladan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering the basic principles and models of mathematical game theory.			
Course outcomes	Students' ability to think strategically, critically analyze existing scientific results, and conduct independent scientific research in the field of mathematical game theory, including programming.			
Course outline				
Theoretical teaching	Introduction and general principles: Subject and goal of studying game theory. A brief overview of the history of game theory. Basic concepts and definitions of mathematical game theory. Terminology. Classification of games. Strategic and formal thinking. Significance and definitions of game rules. The concept of Nash equilibrium. Mathematical model of Nash equilibrium. Mathematical basis of logic games. Games with simultaneous moves (static games). Games with sequential moves (dynamic games). General classes of games and strategies: Cooperative and non-cooperative games. Characteristic games. Games of skill, games of chance, games of strategy. Formal definition of games. Strategic and tactical moves. Applications of mathematical game theory. Applications in computer logic games. Mathematical foundations of logic game algorithms. Other applications.			
Practical teaching (exercises, OFE, study and research work)	Preparation of seminar papers. Modeling and programming of mathematical principles of game theory. Study research work. Games of skill, games of chance, games of strategy, mathematical models and program implementation. Analogy of characteristic games with real situations through examples. Software for mathematical modeling and simulation of static and dynamic games. Software and examples of logic games.			
Textbooks/references				
1	Dixit A., and Skeath S., Games of Strategy, 2nd edition, Norton, New York, 2004.			
2	Vladan Vučković, "Contribution to the Theory and Practice of Advanced Chess Algorithms", PhD dissertation, Faculty of Electronics in Niš, October 2006.			
3	Robert Gibbons, A Primer in Game Theory, ISBN-13: 978-0745011592, Pearson, 1992.			
4	Johan van Benthem and Fernando R. Velazquez Quesada, Logic in Games, DOI: https://doi.org/10.7551/mitpress/9674.001.0001 , The MIT Press, 2014.			
5	R. Duncan Luce and Howard Raiffa, Games and Decisions: Introduction and Critical Survey, Dover Books on Mathematics, Courier Corporation, 1989.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations, seminar papers, study research work.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in E-Learning Technologies		
Lecturer (for lectures)		Milentijević Z. Ivan, Stoimenov V. Leonid, Rančić D. Dejan, Janković S. Dragan, Nejšković M. Valentina		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	To provide students with an in-depth theoretical and practical foundation in emerging information and communication technologies for learning support, including the design, implementation, and rigorous evaluation of algorithmic and systems-oriented learning tools.			
Course outcomes	Upon completing the course, students will be capable of applying methods, principles, and tools for evaluating learning support technologies. They will be prepared to engage in original research in the development of learning support algorithms and systems for educational technology, and to be able to develop innovative methods and solutions.			
Course outline				
Theoretical teaching	Research work on enhancing existing and developing new software tools for learning support. HCI in learning. Adaptation of general-purpose software tools for educational applications; development of new tools for computer-supported collaborative learning, computer-aided testing, etc.; artificial intelligence for learning support. Methods, techniques, and tools for assessing the quality of learning software. Technical and educational evaluation of developed tools. Application of data science for learning evaluation.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	Yang Shen, Xin Yin, Yu Jiang, Lingkai Kong, Sheng Li, Haijun Zeng, Case Studies of Information Technology Application in Education: Utilising the Internet, Big Data, Artificial Intelligence, and Cloud in Challenging Times, Springer, 2023.		
	2	Advanced Methodologies and Technologies in Modern Education Delivery, Mehdi Khosrow-Pour (Ed.), IGI Global, 2018.		
	3	Clark, Donald. Artificial Intelligence for Learning: Using AI and Generative AI to Support Learner Development. Kogan Page Publishers, 2024.		
	4	A curated collection of selected accademic articles		
	5			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Consultations and guided research work			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Topics in Natural Language Processing		
Lecturer (for lectures)		Stojković R. Suzana, Bogdanović D. Miloš		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		The course aims to provide students with a deep understanding of current and advanced concepts in the field of natural language processing. Special attention is given to text modeling, sequence modeling, analysis, design and optimization of large language models. Additionally, within the course, students will have the opportunity to explore specific ways of using large language models in the design and development of semantic search mechanisms and RAG systems.		
Course outcomes		The student will be able to identify and analyze complex problems in the domain of language modeling, in terms of model usage and in terms of choosing a model architecture for a targeted implementation. At the end of the course, the student will be able to independently define a language modeling approach, choose a model architecture, and use existing tools and solutions for the development and optimization of large language models.		
Course outline				
Theoretical teaching		Modern trends in language modeling (bag of words, sequence modeling, vector representation, algorithms used for text tokenization). Modern trends in sequence modeling (recurrent neural networks). Transformer architecture. Types of transformer architecture for the development of large language models. Structure of data sets for training large language models. Training large language models for individual tasks: masked language modeling, instruction following, text generation, inference, classification, summarization. Optimization of large language models - domain adaptation, prompting, N-shot learning, LoRA, PEFT, model distillation, model quantization. Architecture of question answering systems. Types and elements of RAG systems.		
Practical teaching (exercises, OFE, study and research work)		A research work and project development in the areas of: LLMs adaptation, LLM optimization, as well as applying LLMs to solve specific natural language processing tasks (text classification, impression analysis, machine translation, text summarization, question answering, etc.). The work should include: the systematic collection, analysis, and classification of relevant scientific literature; critical evaluation and improvement of existing methods or the development of a novel approach; experimental evaluation of the proposed solution; comparative analysis of the obtained results against relevant existing methods; identification of limitations and open research questions, as well as the definition of directions for future research.		
Textbooks/references				
1	D. Jurafsky and J. H. Martin: Speech and Language Pprocessing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models, Third Edition, McGraw Hill, 2025.			
2	Tong Xiao, Jingbo Zhu, Foundations of Large Language Models, 2025.			
3	Suhas Pai, Designing Large Language Model Applications: A Holistic Approach to LLMs 1st Edition, Kindle Edition, O'Reilly Media Inc., 2025			
4	Sebastian Raschka, Build a Large Language Model (From Scratch), Manning Publications Co., 2025			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Presentation of specific topics, seminars and project analysis		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science	
Type and level of studies		Doctoral Studies	
The name of the course		Applying Artificial Intelligence to Biomedical Data Processing and Analysis	
Lecturer (for lectures)		Milenković M. Aleksandar, Janković S. Dragan	
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS	12	Course status (obligatory/elective)	Elective
Prerequisites	None		
Course objectives	The goal of the course is to provide students with a deep understanding of the possibilities of applying current and advanced artificial intelligence concepts in the processing and analysis of biomedical data and to support active research work in the field of medical informatics and bioengineering with an emphasis on the application of artificial intelligence techniques.		
Course outcomes	The student will be able to: Critically analyze and apply modern artificial intelligence methods in the processing and analysis of complex biomedical data, including biosignals (ECG, EEG, EMG, ENG), medical images (X-ray, CT, NMR, ultrasound, gastroscopic, ophthalmological, histopathological, thermograms), sound, genes. Designs and implements sophisticated algorithms for predicting, classifying, clustering, and visualizing biomedical data using relevant available libraries and tools. Performs critical evaluation of the performance of developed models using advanced metrics and validation techniques while respecting ethical and regulatory standards in medicine and bioinformatics. Develops and tests innovative research hypotheses in the field of intelligent analysis of biomedical data, with the ability to publish results in relevant scientific journals and present them in academic and clinical contexts.		
Course outline			
Theoretical teaching	Tools for collecting, processing, analyzing, visualizing, and exploring biomedical data. Collecting and storing biomedical data. Analyzing constraints related to biomedical data quality, anonymity, volume, and meaningfulness. Anonymizing data. Initial data analysis. Visualization of biomedical data. Application of modern and various methods of artificial intelligence and machine learning in the processing and analysis of biosignals (ECG, EEG, EMG, ENG), medical images (X-ray, CT, NMR, ultrasound, gastroscopic, ophthalmological, histopathological, thermograms). Measuring and comparing the obtained results. Validating the results. Comparing machine learning methods for solving the same problem. Criteria for selecting the best method and the created model. Automation of the selection of algorithms and appropriate hyperparameters of machine learning methods. Available software solutions for the visualization of the obtained results. Creation of synthetic data in a specific domain (metamaterials, histological preparations, image restoration). Medicine 4.0. Collecting biosignals from various sources (smartwatches, mobile phones, medical diagnostic devices, and available datasets). Efficient ways to locally store and use biomedical data.		
Practical teaching (exercises, OFE, study and research work)	Independent research work, consultations, lectures, seminar papers, and work on the development of specific software tools and models.		
Textbooks/references			
1	Russel Stuart, Norvig Peter. Artificial Intelligence: A Modern Approach, Global Edition, Pearson, 2021, ISBN: 978-1292401133		
2	Jamie Flux. Data Acquisition and Preprocessing in Bioinformatics (Genesis Protocol: Next Generation Technology for Biological and Life Sciences), 2024, ISBN: 979-8336876260		
3	Hussein Kaoud. Bioinformatics and Artificial Intelligence In Medical Biology, 2025, ISBN: 979-8305547306		
4	Jamie Flux. Biomedical Engineering Fundamentals Handbook with Python (Genesis Protocol: Next Generation Technology for Biological and Life Sciences), 2024, ISBN: 979-8338085004		
5	Stephanie Willerth. Handbook of Neural Engineering: A Modern Approach, Academic Press, 2024, ISBN: 978-0323957304		
Number of classes of active education per week during semester/trimester/year			
Lectures	Exercises	OFE	Study and research work
			Other classes

3	/	/	0	0
Teaching methods	Presentations on specific topics, seminars, and projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam	Points	
Activity during lectures		Written exam		
Exercises		Oral exam	50	
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science	
Type and level of studies		Doctoral Studies	
The name of the course		Advanced Topics in Computer Networks and Systems Security	
Lecturer (for lectures)		Čirić M. Vladimir, Milovanović I. Emina, Vučković V. Vladan, Rajković J. Petar	
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS		12	Course status (obligatory/elective) Elective
Prerequisites	None		
Course objectives	The aim of the course is to provide students with a deep understanding of current and advanced concepts in the field of computer systems and network security. Special attention is given to the analysis and design of security mechanisms in distributed, virtualized, and heterogeneous environments, as well as to the critical assessment of modern threats, attacks, and techniques for their detection and mitigation.		
Course outcomes	The student will be able to identify and analyze complex security threats in modern infrastructures, develop and apply advanced protection methods, use formal methods and tools for the verification of security protocols, explore new machine learning-based approaches to attack detection, critically analyze modern attack techniques, and develop strategies for their prevention.		
Course outline			
Theoretical teaching	Current Trends in Computer Systems Security. Zero Trust Architectures. Adaptive Security. Advanced Attack Detection Techniques: Machine and Deep Learning, Anomaly Analysis, Explainable Methods. Security in Virtualized and Cloud-Native Environments (Containers, Kubernetes). Security in Edge, Fog, and IoT Environments – Challenges and Approaches. Formal Methods in Protocol Verification (Model Checking, Theorem Proving, ProVerif, Tamarin). Classical and Post-Quantum Cryptography: Algorithms, Standards, and Implications. Protocol Security Analysis (TLS 1.3, QUIC, DNSSEC, BGPsec). Advanced Attacks: Side-Channel Attacks, Supply-Chain Attacks, AI-Assisted Malware. Authentication and Identity Management in Distributed Systems. Forensics and Incident Response in Cloud and Hybrid Environments.		
Practical teaching (exercises, OFE, study and research work)	Practical application of advanced intrusion detection techniques (network traffic analysis, intrusion classification). Verification of security protocols. Implementation of the Zero Trust model in a cloud environment. Configuration and analysis of Kubernetes security policies. Examination of post-quantum cryptographic primitives (NTRU, Kyber). Simulation of complex attacks (spear phishing, privilege escalation, data exfiltration). Tools for security forensics and incident response (Autopsy, Volatility, TheHive).		
Textbooks/references			
1	Stinson, D. R., Paterson, M. B., Cryptography: Theory and Practice (4th Edition), CRC Press, 2018, ISBN: 9781138197015		
2	Bernstein, D. J., Buchmann, J., Dahmen, E. (Eds.), Post-Quantum Cryptography, Springer, 2009, ISBN: 9783540887010		
3	Anderson, R., Security Engineering: A Guide to Building Dependable Distributed Systems (3rd Edition), Wiley, 2020, ISBN: 9781119642787		
4	Bishop, M., Computer Security: Art and Science (2nd Edition), Addison-Wesley, 2018, ISBN: 9780134097143		
5			
Number of classes of active education per week during semester/trimester/year			
Lectures	Exercises	OFE	Study and research work Other classes
3	/	/	0 0
Teaching methods	Presentations on specific topics, seminars, and projects.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Modelling and Design of Microwave Devices and Systems		
Lecturer (for lectures)		Dončov S. Nebojša, Marinković D. Zlatica		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Development of competencies for the critical analysis, modelling, design and optimization of microwave devices and systems. Training the student for independent scientific research work in the field of electromagnetic field modelling, guided electromagnetic waves, RF/microwave circuits and microwave systems.			
Course outcomes	Upon successful completion of the course, the student is able to critically analyse recent scientific results in the field of microwave system design, formulate a research problem and select an appropriate approach for solving it. The student acquires the ability to develop, improve and verify models for the analysis, design and optimization of microwave devices and systems, including models of guided electromagnetic waves, RF/microwave circuits and electromagnetic fields. The student is able to critically interpret the results, compare them with results from the literature, measurements or reference models, and present them in the form of a research report or scientific paper.			
Course outline				
Theoretical teaching	Electromagnetic field theory. Guided electromagnetic waves. Application of circuit theory methods in the RF and microwave frequency ranges. Numerical methods in applied electromagnetics and full-wave modelling of the electromagnetic field. Circuit/field models and simulation of microwave devices. Analysis, design and optimization of passive and active microwave circuits, devices and subsystems. Application of artificial neural networks in the modelling and optimization of microwave devices and systems. Modelling and design of microwave systems in various areas of telecommunications. Verification of simulation models by comparison with measurements, reference models or results from the literature.			
Practical teaching (exercises, OFE, study and research work)	The study research work includes a systematic analysis of recent scientific literature in the field of modelling and design of microwave devices and systems, identification of a research problem, formulation of research questions, and selection of an appropriate analytical, numerical or simulation-based approach. Within the research work, the student develops or modifies a model for the analysis, design or optimization of a microwave circuit, device or system, conducts simulations, and analyses the limitations of the proposed model. Special emphasis is placed on comparing the results with measurements, reference models or results from recent literature, as well as on the critical interpretation of results and preparation of a research report.			
Textbooks/references				
1	D. Pozar, Microwave Engineering, 4th edition, Wiley, 2011.			
2	W. Egan, Practical RF System Design, 1st edition, Wiley-IEEE Press, 2003.			
3	J. C. Pedro, D. E. Root, J. Xu, L. C. Nunes, Nonlinear Circuit Simulation and Modeling: Fundamentals for Microwave Design, Cambridge University Press, 2018.			
4	C. A. Balanis, Balanis' Advanced Engineering Electromagnetics. 3rd edition, Wiley, 2024.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, analysis of selected scientific papers, computer simulations, project-based research work, consultations, discussion of results, critical analysis of proposed models and methods, preparation and defence of a seminar/research paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Error Control Coding Techniques		
Lecturer (for lectures)		Jovanović Ž. Aleksandra		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Disseminating knowledge and familiarizing students with the latest advancements and research in the field of error control coding, with a special emphasis on advanced iterative decoding algorithms.			
Course outcomes	The student will gain a thorough understanding of complex iterative decoding algorithms and will be able to implement them. They will acquire the knowledge necessary to follow professional literature and actively engage in scientific research in the field of error control coding.			
Course outline				
Theoretical teaching	Error correction codes in modern communication and data storage systems. Decoding algorithms for codes that can be represented by a trellis: Viterbi decoding algorithm, SOVA decoding algorithm, BCJR decoding algorithm. Iterative decoding algorithms for graph-based codes: Bit-flipping decoding algorithm, message passing concept and turbo principle, sum-product decoding algorithm, min-sum decoding algorithm, Gallager's A and B decoding algorithms.			
Practical teaching (exercises, OFE, study and research work)	Independent study and critical analysis of scientific literature in the field of advanced error control coding techniques. Implementation of research projects involving the software implementation and performance evaluation of decoding algorithms for turbo, LDPC, and polar codes, as well as the investigation of novel approaches for improving performance and reducing decoding complexity. Presentation and discussion of the obtained results.			
Textbooks/references				
1	W. E. Ryan, S. Lin, Channel Codes - Classical and Modern, Cambridge University Press, 2009.			
2	Silvio A. Abrantes, From BCJR to turbo decoding: MAP algorithms made easier, https://paginas.fe.up.pt/~sam/textos/From%20BCJR%20to%20turbo.pdf			
3	E. Arikan, Channel Polarization: A Method for Constructing Capacity-Achieving Codes for Symmetric Binary-Input Memoryless Channels, in IEEE Transactions on Information Theory, vol. 55, no. 7, pp. 3051-3073, July 2009, doi: 10.1109/TIT.2009.2021379.			
4	T. Richardson, R. Urbanke, Modern Coding Theory, Cambridge University Press, Cambridge, 2008.			
5	T. K. Moon, Error Correction Coding: Mathematical Methods and Algorithms, Wiley, 2005.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Consultations. Scientific research.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	10	Written exam		
Exercises		Oral exam		40
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Microwave Electronics		
Lecturer (for lectures)		Pronić-Rančić R. Olivera, Maleš-Ilić P. Nataša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to advanced design techniques for linear and nonlinear microwave electronic circuits.			
Course outcomes	The student's capability for original scientific research in the field of microwave electronics through the critical analysis of contemporary scientific achievements. The student acquires competencies for the independent generation of new solutions, the modification of existing ones, and the development of advanced methods for the design and optimization of microwave electronic circuits.			
Course outline				
Theoretical teaching	Modern approach to microwave circuit design (CAD techniques) - modeling, simulation and optimization in the design process. Microwave semiconductor components: microwave diodes and transistors. Applications of microwave semiconductor components. RF and microwave amplifiers. Small-signal amplifiers and nonlinear amplifiers. Low-noise amplifiers. Broadband and balanced amplifiers. Harmonic balance analysis. Power amplifiers - basic characteristics and applications. Power amplifier classes. RF and microwave oscillators. Mixers. Detectors. Modulators. Microwave control circuits (switches, phase shifters, limiters, attenuators). Microwave integrated circuits. Microwave transmitters and receivers.			
Practical teaching (exercises, OFE, study and research work)	Solving selected problems through seminar papers. Analysis and optimization of microwave circuits and assemblies using specialized software packages. Practical work in the laboratory.			
Textbooks/references				
1	Giovanni Ghione, Marco Pirola, Microwave electronics, Cambridge University Press, 2018.			
2	Andrey D. Grigoriev , Vyacheslav A. Ivanov , Sergey I. Molokovsky, Microwave Electronics, Springer, 2018.			
3	Subhash Chandra Bera , Microwave Active Devices and Circuits for Communication, Springer, 2019.			
4	David M. Pozar, "Microwave Engineering - fourth edition", John Wiley & Sons, Inc., 2011.			
5	Olivera Pronić-Rančić, Vera Marković, Nataša Maleš – Ilić, Bratislav Milovanović: "Mikrotalasna elektronika", Elektronski fakultet, 2013.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, seminar papers.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Wireless Communications		
Lecturer (for lectures)		Maleš-Ilić P. Nataša, Stanković Ž. Zoran, Joković J. Jugoslav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Deepening of knowledge related to the concept, architecture and functioning of modern wireless communication systems and learning about methods for solving problems in selected areas.			
Course outcomes	Students will be able to: •Analyze the operational principles and architectures of contemporary wireless communication systems in the microwave frequency range. •Apply electromagnetic wave propagation models to plan and calculate the parameters of wireless links. •Design essential components, circuits, and subsystems required for the operation of advanced wireless technologies. •Evaluate the characteristics and performance of various services and technologies in fixed and mobile communication networks. •Assess levels of non-ionizing radiation by utilizing standardized measurement methods. •Analyze the biological effects of RF and microwave radiation in accordance with current scientific evidence and regulatory standards.			
Course outline				
Theoretical teaching	Overview of microwave wireless communication systems. Advanced wireless technologies and services. Propagation models in the RF and microwave frequency range. Selected topics in the field of fixed and mobile communication systems. Wireless communication systems architecture and design of RF components and subsystems for wireless communications. Methods for the characterization of non-ionizing radiation levels of wireless systems and the biological effects of radiation.			
Practical teaching (exercises, OFE, study and research work)	Insight into selected literature. Examining a specific problem. Independent research work.			
Textbooks/references				
1	Andreas F. Molisch, Wireless Communications: From Fundamentals to Beyond 5G, 3rd Edition, Wiley-IEEE Press, 2022.			
2	Randy L. Haupt, Wireless Communications Systems: An Introduction, John Wiley & Sons, Inc., 2020.			
3	Khaldoun Al Agha, Guy Pujolle, Tara Ali-Yahiya, Mobile and Wireless Networks, ISTE Ltd, 2016.			
4	A. Osseiran, J. Monserrat, P. Marsch, 5G Mobile and Wireless Communications Technology, Cambridge University Press, 2016.			
5	Published papers in a certain field			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Presentations, seminar work and students' projects			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program			Electrical Engineering and Computer Science		
Type and level of studies			Doctoral Studies		
The name of the course			Modern Multiple Access Techniques		
Lecturer (for lectures)			Panajotović S. Aleksandra		
Lecturer/associate (for exercises)					
Lecturer/associate (for OFE)					
Number of ECTS		12	Course status (obligatory/elective)		Elective
Prerequisites	None				
Course objectives	To become familiar with multiple access techniques applied in modern communication systems, as well as methods of resource allocation in them.				
Course outcomes	The student is capable of critically analyzing, comparing, and evaluating multiple access techniques, developing and enhancing algorithmic solutions for OMA, MIMO, NOMA, and other advanced multiple access techniques, and independently applying the acquired knowledge in scientific research and the design of next-generation communication systems.				
Course outline					
Theoretical teaching	The concept of OMA (Orthogonal Multiple Access) as a fundamental multiple access technique. The OMA techniques: FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access), CDMA (Code Division Multiple Access), OFDM (Orthogonal Frequency Division Multiplexing) and its modifications (OFDMA, SOFDMA, SC-FDMA). MIMO (Multiple Input Multiple Output) technique for multiple access based on spatial diversity. Multi-user and massive MIMO systems. NOMA (Non-orthogonal Multiple Access) multiple access techniques: PD-NOMA (power-domain NOMA), CD-NOMA (code-domain NOMA), CR-NOMA (Cooperative Relay NOMA), MIMO-NOMA, etc. Other alternative techniques: IDMA (Interleave Division Multiple Access), PDMA (Pattern Division Multiple Access), LDM (Layered Division Multiplexing), etc.				
Practical teaching (exercises, OFE, study and research work)	Definition of a project/research task, analysis and discussion of relevant scientific and professional literature, and independent student work on the assigned project/research task. Dissemination of the project/research results through the preparation of a scientific paper presented at a conference or published in a journal, or through a written report and an oral presentation of the results followed by discussion.				
Textbooks/references					
1	E. Bjornson, J. Hoydis, L. Sanguinetti, Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency, Foundation and Trends in Signal Processing Series, 2017.				
2	R. W. Heath Jr, A. Lozano, Foundations of MIMO Communication, Cambridge University Press, 2018.				
3	M. Vaezi, Z. Ding, H. V. Poor, Multiple Access Techniques for 5G Wireless Networks and Beyond, Springer International Publishing, 2019.				
4	Y. Liu, L. Liu, Z. Ding, X. Shen, Next Generation Multiple Access, Wiley-IEEE Press, 2024.				
5	Collection of selected scientific papers.				
Number of classes of active education per week during semester/trimester/year					
Lectures	Exercises	OFE	Study and research work		Other classes
3	/	/	0		0
Teaching methods	Lectures (ppt presentation, animation and practical examples), consultations, study and research work.				
Grade (maximum number of points 100)					
Pre-exam duties		Points	Final exam		Points
Activity during lectures			Written exam		
Exercises			Oral exam		50
Colloquia					
Projects		50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Telecommunications Theory		
Lecturer (for lectures)		Đorđević T. Goran, Milović M. Daniela		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Deepening knowledge of Telecommunications Theory and its application to the analysis, design, and optimization of modern wireless and optical systems. Preparing for independent research work in this field.			
Course outcomes	After passing the exam, students will: 1) know how to apply the acquired knowledge and skills from Telecommunications Theory in the study of modern optical and wireless systems; 2) know how to determine the limits up to which the performance of these systems can be improved; 3) know how to analyze and design receivers in channels with intersymbol interference using analytical and simulation methods.			
Course outline				
Theoretical teaching	Statistical characterization of channels in modern radio-frequency and optical wireless systems. Error probability and capacity estimation using analytical and simulation approaches. Controlled intersymbol interference. Optimal detection under various propagation conditions. Combined equalization and coding. Space-time codes. Performance evaluation of multiple-antenna wireless systems. Study of information transmission via visible light communications (VLC) from the perspective of Telecommunications Theory.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	A. Papoulis, S. U. Pillai, Probability, Random Variables and Stochastic Processes, 4th edition, McGraw-Hill, 2002.			
2	H. L. Van Trees, K. L. Bell, Z. Tian, Detection Estimation and Modulation Theory, Part I: Detection, Estimation, and Filtering Theory, 2nd Edition, Wiley, 2013.			
3	Z. Ghassemlooy, W. Popoola, S. Rajbhandari, Optical Wireless Communications: System and Channel Modelling with MATLAB, CRC Press, 2017.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Consultations. Seminar.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	20
Exercises			Oral exam	30
Colloquia				
Projects		50		

Specification for the book of courses

Study program			Electrical Engineering and Computer Science	
Type and level of studies			Doctoral Studies	
The name of the course			Digital Modulation Techniques	
Lecturer (for lectures)			Milić N. Dejan, Panajotović S. Aleksandra	
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquire theoretical knowledge about modern digital modulation techniques.			
Course outcomes	Ability to apply an adequate modulation technique, based on the acquired knowledge, depending on the environment and communication system. Ability to determine the performance of modern digital modulation techniques using appropriate software packages. Ability to understand future modulation techniques.			
Course outline				
Theoretical teaching	MSK (Minimum Shift Keying). CPM (Continuous Phase Modulation), i.e. GMSK. QAM (Quadrature Amplitude Modulation) modulation and its modifications. FTN (Faster Than Nyquist) modulation. OFDM (Orthogonal Frequency Division Multiplexing) modulation and its modifications. Spectrally efficient modulation without constant envelope. Performances of modulation techniques appropriate for Wi-Fi 6 and 7, 4G-LTE and 5G-NR.			
Practical teaching (exercises, OFE, study and research work)	Defining the project task, analysis and discussion of relevant scientific and professional literature, independent work of students on the project. Dissemination of the results of the project in the form of a scientific research paper presented at a conference/journal or in the form of a written and oral presentation of the results supplemented by discussion.			
Textbooks/references				
1	J. G. Proakis, Digital Communications, fourth edition, McGraw Hill, 2011.			
2	C. Gontrand, Digital Communication Techniques, Wiley, 2020			
3	D. H. Morais, Key 5G/5G-Advanced Physical Layer Technologies, Springer, 2024			
4	N. Wu, Y. Ma, R. Jiang, Advanced Receiver Design for Multicarrier FTN Signaling in 6G Systems, Springer, 2025.			
5	Collection of selected scientific papers.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations, study and research work.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Telecommunications		
Lecturer (for lectures)		Perić H. Zoran, Nikolić R. Jelena, Jovanović Ž. Aleksandra		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites				
Course objectives	Gaining theoretical knowledge and insight into the latest developments and research in digital telecommunications.			
Course outcomes	Extended theoretical knowledge in the field of digital telecommunications, with the ability to effectively solve problems within the scope of the study area.			
Course outline				
Theoretical teaching	Lossy coding. Scalar, polar and vector quantization. Adaptive scalar quantization: Adaptive pulse code modulation (APCM). Adaptive differential encoding: Adaptive differential pulse code modulation (ADPCM). Adaptive delta modulation. Coding with delayed decision. Subband coding. Transform coding. Channel capacity and coding. Channel coding. Compression of audio and speech signals. Compression of video signals.			
Practical teaching (exercises, OFE, study and research work)	Lectures. Consultations. Project assignments.			
Textbooks/references				
1	J. Proakis, M. Salehi, Digital Communications, McGraw-Hill Education, 5th edition, 2007.			
2	N.S. Jayant, P. Noll, Digital Coding of Waveforms, Prentice-Hall, New Jersey, 1984.Publishers, 1992.			
3	M.Safak, Digital Communications,Wiley, 1st edition, 2017			
4	A. Gersho, R. M. Gray, Vector Quantization and Signal Compression, Kluwer Academic Publishers, 1992.			
5	K. Sayood, Introduction to Data Compression, Elsevier, Morgan Kaufmann; 5th edition, 2018.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Project work. Consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Signal Processing		
Lecturer (for lectures)		Perić H. Zoran, Dončov S. Nebojša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring theoretical knowledge, introduction to the latest achievements and research in the field of digital signal processing.			
Course outcomes	Expanded theoretical knowledge from the field of digital signal processing. Ability for solving problems from the studied field.			
Course outline				
Theoretical teaching	Discrete signals and systems. Discrete direct and inverse Fourier transform. Algorithms of direct and inverse fast Fourier transform. Direct and inverse z-transform. Discrete transfer functions. Discrete transforms (DCT, DFT, DWT). Digital recursive and nonrecursive filters and their realisations. Wave digital filters and realisations. Frequency and time analysis. Appliance of digital filters in the construction of linear predictors, both fixed and adaptive. Estimation of discrete signal's parameters. Digital signal processing in frequency domain. Basics of digital signal processing needed for subsegment coding (filter banks). Digital signal processors for filter realisations. Software package for digital signal processing MATLAB.			
Practical teaching (exercises, OFE, study and research work)	Lectures. Consultations. Work on project.			
Textbooks/references				
1	Nader Hamdy, Applied Signal Pocessing, CRC Press 2009			
2	M. V. Popovic, Digital Signal Processing (in Serbian), Science, Belgrade, 1994			
3	Lj. Stanković, Digital Signal Processing with Selected Topics: Adaptive Systems Time Frequency Analysis Sparse Signal Processing, Create Space Independent Publishing Platform, 2015.			
4	M.Vetterli, J. Kovacevic, V. K. Goyal, Foundations of Signal Processing, Cambridge University Press, 2014.			
5	D. G. Manolakis, V. K. Ingle, Applied Digital Signal Processing: Theory and Practice Cambridge University Press; 1st edition, 2011.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, project, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Sound Generation and Perception		
Lecturer (for lectures)		Čirić G. Dejan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Mastering knowledge about sound, familiarizing with the newest achievements and research in sound generating, transmission, modeling and processing, as well as sound perception.		
Course outcomes		Theoretical knowledge. Solving practical problems: acoustical design, noise (sound) protection, system design, measurements, sound acquisition. Proper use of equipment. Application of knowledge in real situations such as industrial applications.		
Course outline				
Theoretical teaching		Generating speech and music signals, as well as measurement acoustical signals. Sound transmission indoors and outdoors. Sound perception. Sound acquisition (acoustical sensors). Design and analysis of modern devices for sound recording and reproduction. Acoustics of enclosed spaces. Sound reinforcement. Noise as unwanted sound and adequate protection. Creating sound effects with predefined characteristics. Standards and norms of acoustic quality. Acoustic measurement techniques. The application of technology based on sound in the industry.		
Practical teaching (exercises, OFE, study and research work)		Problem solving through students' reasearch projects (Sound generating (speech and music signals). Sound sources. Sound transmission. Sound perception (formation of the sound image). Acquisition of sound (analog and digital sensors, spatial dimension). Characteristics of modern devices for sound recording and sound reproduction. Acoustical characteristics of enclosed spaces. Characteristics of speech and music. Acoustical measurement techniques).		
Textbooks/references				
1		T. D. Rossing: Springer handbook of acoustics, Springer, New York, 2007.		
2		L. E. Kinsler, A. R. Frey, A. B. Coppens, J. V. Sanders: Fundamentals of acoustics, 4th edition, John Wiley & Sons, New York, 2000.		
3		H. Kuttruff: Acoustics – an introduction, Taylor & Francis, London, 2007.		
4		D. R. Raichel: The science and applications of acoustics, 2nd edition, Springer, New York, 2006.		
5		J. Blauert: Communication acoustics, Springer, Berlin, 2005.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Lectures. Consultations. Student research projects.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises		30	Oral exam	40
Colloquia				
Projects		30		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Compressive Sensing with Applications		
Lecturer (for lectures)		Nikolić R. Jelena		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Providing knowledge about compressive sensing of analog signals, sparse signal representation, and sparse signal coding. Training students to write scientific papers in this very current research field.			
Course outcomes	Students first acquire knowledge about modern approaches in data acquisition, compressive sensing of analog signals, sparse signal representation, and sparse signal coding. They also learn about the challenges inherent to this research field. Subsequently, students apply this knowledge through scientific research focused on the A/D conversion of various signals.			
Course outline				
Theoretical teaching	Modern approaches to data acquisition. Significance of compressive sensing of analog signals and a sparse representation of signals. Mathematical formulation of compressive sensing. Required conditions for successful application of compressive sensing- RIP, SPARK and MIP. The problem of convex optimization in compressive sensing. Minimization of vector norms l_0 , l_1 and l_2 . Deterministic approach in constructing the measurement matrix. Probabilistic approach in constructing the measurement matrix. Sparse representations of signals for the reconstruction of information from incomplete data. Sparse signal coding. Compressive sensing for a predefined dictionary. Greedy algorithms and algorithms with a relaxed condition of sparsity. Orthogonal matching pursuit algorithm. Matching pursuit algorithm. Weak matching pursuit algorithm. Analysis of the obtained approximations. Dictionary learning. Application of compressive sensing algorithms in A / D conversion of variety of signals, also in MRI algorithms and face recognition.			
Practical teaching (exercises, OFE, study and research work)	Lectures, Consultations, Project work.			
Textbooks/references				
1	Y. C. Eldar, G. Kutyniok, Compressed Sensing: Theory and Applications, Cambridge University Press, 2012.			
2	Y. C. Eldar, Sampling Theory: Beyond Bandlimited Systems, Cambridge University Press, 2015.			
3	M. Elad, Sparse and Redundant Representations: From Theory to Applications in Signal and Image Processing, Springer, 2010.			
4	I. Rish, G. Grabarnik, Sparse Modeling: Theory, Algorithms, and Applications, CRC Press, 2014.			
5	S. Stanković, I. Orović, E. Sejdić, Multimedia Signals and Systems: Basic and Advanced Algorithms for Signal Processing, Springer, 2016.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, Power Point presentations, Consultations.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	5	Written exam		
Exercises	30	Oral exam		35
Colloquia				
Projects	30			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Artificial Intelligence and Machine Learning in Communication Systems		
Lecturer (for lectures)		Marinković D. Zlatica, Stanković Ž. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring the necessary knowledge for independent application of artificial intelligence and machine learning methods in communication systems.			
Course outcomes	Knowledge of the fundamental principles of artificial intelligence and machine learning methods suitable for applications in communication systems. Students will be able to select and independently apply an appropriate method for a given problem. They will also be able to discuss the obtained results and compare different methods.			
Course outline				
Theoretical teaching	Basic principles of artificial intelligence and machine learning. Regression, classification, and clustering. Machine learning methods. Artificial neural networks. Evolutionary algorithms. Principles and stages of model development using machine learning methods. Metrics. Examples of applying artificial intelligence and machine learning methods in communication systems. Development of individual projects applying artificial intelligence and machine learning to solve specific problems in communication systems.			
Practical teaching (exercises, OFE, study and research work)	Independent research work (literature review, analysis of a specific problem and implementation of a solution, writing and presenting a scientific paper).			
Textbooks/references				
1	S. Shalev-Shwartz, S. Ben-David, Understanding Machine Learning - From Theory to Algorithms, Cambridge University Press, 2014.			
	Sebastian Raschka, Machine Learning with PyTorch and Scikit-Learn, Packt, 2022.			
2	M. Nielsen, Neural Networks and Deep Learning, Determination Press, 2015.			
3	Sebastian Raschka, Machine Learning with PyTorch and Scikit-Learn, Packt, 2022.			
4	Q. J. Zhang, K. C. Gupta, Neural Networks for RF and Microwave Design, Artech House, 2000.			
5	Selected scientific articles.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures; independent research work; consultations. (Note: publishing a scientific paper in a journal or a presentation at a conference replaces the oral part of the exam.)			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Audio Communications		
Lecturer (for lectures)		Ćirić G. Dejan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Mastering knowledge, introduction to modern achievements and research within the field of audio communications, audio signals, analysis and synthesis of auditory scenes, audio analytics as well as audio signal processing.			
Course outcomes	Theoretical knowledge. Solving practical problems in the field of audio signals and systems: analysis, synthesis and design. Skills of appropriate use of audio devices and systems. Mastering the applications of modern technologies based on sound.			
Course outline				
Theoretical teaching	Audio signals (definitions, concepts). Characteristics of speech and music signals. Audio communication systems (structure and characteristics). Input and output acoustical environment (sound sources and receivers, spatial environment). Audio devices. Audio analytics. Auditory scenes (analysis and synthesis). Detection and classification of audio events. Audio signal processing. Sound synthesis. Subjective effects of sound. Spatial sound image and 3D sound. Auditory virtual environments. Audio restoration. Perceptual coding and audio compression. Sound sources separation and speech dereverberation. Analysis and processing of speech. Audio signal quality (speech quality - intelligibility). Audiometry and audiology. Hearing aids. Applications of sound based technology in medicine.			
Practical teaching (exercises, OFE, study and research work)	Solving problems through the students' research projects from the following teaching units: audio communication systems; effects of input and output acoustical environment; auditory scenes and virtual spaces; audio signal processing; sound synthesis; subjective effects of sound; spatial sound image; audio signal quality estimation; audio event detection; audiometry and audiology.			
Textbooks/references				
1	Y. Huang, J. Benesty: Audio signal processing for next-generation multimedia communication systems, Kluwer Academic Publishers, Boston, 2004.			
2	M. Kahrs, K. Brandenburg: Applications of digital signal processing to audio and acoustics, Kluwer Academic Publishers, USA, 2002.			
3	A. R. Moller: Hearing: anatomy, physiology, and disorders of the auditory system, 2nd edition, Academic Press, San Diego, 2006.			
4	S. Savage: The art of digital audio recording, Oxford University Press, New York, 2011.			
5	D. Jarrett, E. Habets, P. Naylor: Theory and applications of spherical microphone array processing, Springer, Switzerland, 2017.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Consultations. Student research projects.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises	30	Oral exam		40
Colloquia				
Projects	30			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Antennas and Propagation		
Lecturer (for lectures)		Dončov S. Nebojša, Stanković Ž. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Development of competencies for the critical analysis, modelling, design and optimization of antennas, antenna arrays and antenna systems, as well as for modelling electromagnetic wave propagation under real-world conditions above the Earth's surface. Training the student to apply analytical, numerical, empirical, neural and hybrid methods in solving research problems in the field of antennas and electromagnetic wave propagation.			
Course outcomes	Upon successful completion of the course, the student is able to critically analyse recent scientific results in the field of antennas, antenna arrays and electromagnetic wave propagation, formulate a research problem, and select an appropriate tool and/or analytical, numerical, empirical, neural-network-based or hybrid approach for solving it. The student acquires the ability to develop, improve and verify models for the analysis, synthesis and optimization of antennas and antenna arrays, as well as models for predicting the electromagnetic field under realistic conditions. The student is able to critically interpret the results, compare them with results from the literature, measurements or reference models, and present them in the form of a research report or scientific paper.			
Course outline				
Theoretical teaching	Analysis of antennas and antenna arrays (analytical and numerical methods). Synthesis of antennas and antenna arrays. Software tools for analysis and synthesis of antenna, antenna arrays and antenna systems. The design procedures for different classes of antennas that have practical applications in modern wireless communication systems. Adaptive antenna structure. Advanced techniques in DOA estimation. Electromagnetic wave propagation modeling. Electromagnetic field prediction in different local-specific regions and for different services. Neural models for electromagnetic field prediction. Numerical, empirical, neural and hybrid methods in electromagnetic wave propagation modeling. Implementation procedures of local-specific neural and hybrid empirical-neural (HEN) models.			
Practical teaching (exercises, OFE, study and research work)	The study research work includes a systematic analysis of recent scientific literature in the field of antennas, antenna arrays and electromagnetic wave propagation, identification of a research problem, formulation of research questions, and selection of an appropriate analytical, numerical, empirical, neural-network-based or hybrid approach. Within the research work, the student develops or modifies a model for the analysis, synthesis or optimization of antennas and antenna arrays, or a model for predicting the electromagnetic field under site-specific conditions. Special emphasis is placed on conducting simulations, analysing the sensitivity and limitations of the model, comparing the results with measurements, reference models or results from the literature, as well as on the critical interpretation of results and preparation of a research report.			
Textbooks/references				
1	C. Balanis, Antenna theory: Analysis and Design, 4rd edition, Wiley, 2016.			
2	J. Kraus, Antennas, Mc Graw Hill, 1988.			
3	W. Stutzman, G. Thiele, Antenna Theory and Design, 3rd Edition, Wiley, 2012.			
4	B. Allen, M. Ghavami, Adaptive Array Systems: fundamentals and applications, Wiley, 2005.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Presentations on spcific topics, analysis of selected scientific papers, computer simulations, project-based research work, consultations, discussion of results, critical analysis of proposed models and methods, preparation and defence of a seminar/research paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			



Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Applications of Neural Networks in Telecommunications		
Lecturer (for lectures)		Marinković D. Zlatica, Stanković Ž. Zoran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Acquiring the necessary knowledge needed for independent application of artificial neural networks in the field of telecommunications.			
Course outcomes	Knowledge about basic principles of neural networks. Ability to train and test neural networks and to develop models based on neural networks. Ability to apply independently the neural networks to develop solutions for particular problems in the field of telecommunications.			
Course outline				
Theoretical teaching	Artificial neural networks (ANNs). Types of ANNs. Multilayer neural networks. Recurrent neural networks. Convolutional neural networks. Algorithms for ANN training. Test and validation of ANNs. Models based on neural networks. Black-box neural models. Knowledge-based neural models. Hybrid empirical-neural models. Analysis of various examples of ANN applications in the field of telecommunications. Software packages to be used for work with ANNs. Implementing neural models in specialized CAD software packages for use in telecommunications.			
Practical teaching (exercises, OFE, study and research work)	Independent research work (analysis of the available literature, analysis of a particular problem and finding solutions, writing and presentations of scientific work).			
Textbooks/references				
1	Q. J. Zhang, K. C. Gupta, Neural Networks for RF and Microwave Design, Artech House, 2000.			
2	C. Christodoulou, M. Gerogiopoulos, Applications of Neural Networks in Electromagnetics, Artech House, 2001.			
3	Z. Marinković, V. Marković, A. Caddemi, "Artificial Neural Networks in Small-Signal and Noise Modeling of Microwave Transistors", Chapter 6 in „Artificial Neural Networks“ edited by Seoyun J. Kwon, Nova Science Publishers Inc., 2011, pp. 219-236			
4	Sebastian Raschka, Machine Learning with PyTorch and Scikit-Learn, Packt, 2022.			
5	Selected scientific papers			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures; independent research work; consultations. (Note: publishing a scientific paper in a journal or a presentation at a conference replaces the oral part of the exam.)			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Satellite Communication Systems		
Lecturer (for lectures)		Pronić-Rančić R. Olivera, Joković J. Jugoslav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Familiarization with cutting-edge achievements and research in satellite communication systems.			
Course outcomes	The student's capability for original scientific research in the field of satellite communication systems through the critical analysis of contemporary literature. The student acquires competencies to independently define research problems, generate new solutions, and develop advanced methods for the design and optimization of satellite links and networks.			
Course outline				
Theoretical teaching	Architecture of satellite communication systems. Satellite classification. Satellite orbits. Satellite link analysis. Overview of modulation techniques and error control methods. Multiple access techniques in satellite communications (TDMA, FDMA, CDMA). High throughput satellites. Communication satellites. Data transmission via communication satellites. Satellite television. Satellite navigation systems. GPS, GLONASS, GALILEO. Integration of GPS and geographic information systems. Special purpose satellite systems (remote sensing satellites, meteorological and military satellites).			
Practical teaching (exercises, OFE, study and research work)	The research work includes an advanced and targeted critical analysis of the latest scientific literature in order to identify open problems in contemporary satellite networks (such as LEO/MEO satellite constellations, inter-satellite links, or integration with 5G/6G networks). Research activities involve the application of advanced mathematical and simulation methods, as well as deep learning methods for satellite link analysis, prediction of atmospheric propagation phenomena, and optimization of system parameters.			
Textbooks/references				
1	A. K. Maini, V. Agrawal, "Satellite technology – principles and applications", Third edition, J.Wiley & Sons, 2014.			
2	D. Minoli: Innovations in satellite communication and satellite technology : the industry implications of DVB-S2X, high throughput satellites, Ultra HD, M2M, and IP, John Wiley & Sons, 2015.			
3	Timothy Pratt, Jeremy Allnutt : Satellite Communications, THird edition, Wiley, 2020.			
4	Mohinder S. Grewal, Angus P. Andrews, Chris G. Bartone : Global Navigation Satellite Systems, Inertial Navigation, and Integration, Wiley, 2020.			
5	G. Maral, M. Bousquet, Z. Sun, Satellite Communications Systems: Systems, Techniques and Technology, 6th Edition, John Wiley & Sons, 2020.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, seminar papers, consultations			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		RF and Microwave Amplifiers		
Lecturer (for lectures)		Maleš-Ilić P. Nataša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring theoretical and practical knowledge in the field of RF and microwave amplifiers.			
Course outcomes	Students will be able to: Model the behavior of different types of microwave transistors through small-signal analysis, nonlinear characteristics, and noise parameters, Analyze the operation of power amplifiers of different classes and their characteristics in terms of efficiency and linearity, Design RF and microwave amplifiers, Apply appropriate linearization techniques to improve power efficiency and reduce nonlinear distortion, Evaluate the impact of different design techniques and strategies on the performance (efficiency, gain, noise) of microwave amplifiers.			
Course outline				
Theoretical teaching	Models of microwave transistors (MOSFET, MESFET, HEMT, BJT, HBT)-models for small signals, nonlinear models, noise modeling. Procedure of low-noise amplifier design. Power amplifiers in class-A, AB, B, C. High-efficient power amplifiers (Class-F, inverse F, D, E, J, continuous modes of operation). Techniques for linearization of microwave amplifiers, Techniques for increasing efficiency of microwave amplifiers.			
Practical teaching (exercises, OFE, study and research work)	Solving selected problems in the form of seminar. Analysis and optimization of RF and microwave amplifiers by using specialized software packages. Practical work in laboratory.			
Textbooks/references				
1	Andrei Grebennikov, Marc J. Franco, Switchmode RF and Microwave Power Amplifiers, 3rd edition, Academic Press, 2021			
2	Andrei Grebennikov, RF and Microwave Power Amplifier Design, second edition, McGraw Hill, 2015			
3	Steve Cripps, RF Power Amplifiers for Wireless Communications, Artech House 2006			
4	A. Grebennikov, Nathan O. Sokal, Switchmode RF Power Amplifiers, Elsevier Inc., 2012			
5	Steve Cripps, RF Power Amplifiers for Wireless Communications, Artech House 2006			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Auditory exercises. Practical work in laboratory. Homework. Consultations.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises	30	Oral exam		50
Colloquia				
Projects	20			

Specification for the book of courses

Study program			Electrical Engineering and Computer Science	
Type and level of studies			Doctoral Studies	
The name of the course			Electromagnetic Compatibility and Signal Integrity	
Lecturer (for lectures)			Dončov S. Nebojša, Joković J. Jugoslav	
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Development of competencies for critical analysis, modelling and solving problems in electromagnetic compatibility and signal integrity, primarily through the application of numerical and simulation methods, with appropriate analytical support. Training the student for independent scientific research work in this field.		
Course outcomes		Upon successful completion of the course, the student is able to critically analyse recent scientific results in the field of electromagnetic compatibility and signal integrity, formulate a research problem, and apply appropriate analytical, numerical and simulation methods. The student acquires the ability to develop, improve and verify models for the analysis of electromagnetic compatibility and signal integrity problems, as well as for the design of electronic circuits, modules and systems in accordance with relevant standards and design principles. The student is able to critically interpret the obtained results and present them in the form of a research report or scientific paper.		
Course outline				
Theoretical teaching		General EMC concepts and techniques. Sources of electromagnetic interference (EMI). EMI signal representation and characterization. The interference coupling mechanisms. Interference control techniques. Coupling of electromagnetic fields with multiconductor lines. Numerical simulation techniques (TLM, FDTD, FEM, MoM). Application of AI/ML in EMC modedlling. Numerical simulation of the coupling between the integrated electronic systems. Principles of designing compact multifunctional integrated circuits (System in a Package - SiP and System on Chip - SoC). Multilayer printed circuit boards (PCBs) and multilayer printed wire boards (PWBs). Clock and power distribution. Standards and regulations for SiP/Soc/EMC.		
Practical teaching (exercises, OFE, study and research work)		he study research work includes a systematic analysis of recent scientific literature in the field of EMC and signal integrity, identification of a research problem and scientific gap, formulation of research questions, selection of a numerical, simulation-based or appropriate analytical approach, development or modification of models, and performance of simulations using methods such as TLM, FDTD, FEM, MoM or combined circuit/field models. Within the research work, AI/ML approaches for modelling, prediction, optimization or interpretation of EMC behaviour of electronic circuits, modules and systems will also be considered. Special emphasis is placed on the sensitivity analysis and limitations of the obtained results, comparison with reference models, measurements, standards or results from recent literature, as well as on the critical interpretation of results and preparation of a research report.		
Textbooks/references				
1		C. Christopoulos, Principles and Techniques of Electromagnetic Compatibility, 3rd edition, CRC Press, 2024.		
2		M. Mardiguian, ElectroMagnetic Compatibility: Understanding, Design, and Testing with Practical Solutions, 2nd edition, Springer, 2025.		
3		L. Ashok Kumar, S. Uma Maheswari, Electromagnetic Interference and Electromagnetic Compatibility: Principles, Design, Simulation, and Applications, CRC Press, 2023.		
4		M. N.O. Sadiku, Computational Electromagnetics with MATLAB, 4th edition, CRC Press, 2018.		
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, analysis of selected scientific papers, numerical simulations on computer, project-based research work, consultations, discussion of results, critical analysis of proposed models and methods, preparation and defence of a seminar/research paper.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	

Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program			Electrical Engineering and Computer Science	
Type and level of studies			Doctoral Studies	
The name of the course			Detection of Signals in Noise	
Lecturer (for lectures)			Perić H. Zoran, Milić N. Dejan	
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring knowledge in the fields of application of linear systems and decision making theories for signal detection from interference.			
Course outcomes	Detection of a known and an unknown signal in white and colored Gaussian noise. Maximization of signal-to-noise ratio and custom filters. Optimum filter for colored noise.			
Course outline				
Theoretical teaching	Linear systems. The noise factor. Optimal linear systems. Nonlinear Systems - direct method. Nonlinear systems - transformation method. Statistical signal detection. Optimal signal reception in the noise. Detection of a known and an unknown signal in white and colored Gaussian noise. Maximization of signal-to-noise ratio and custom filters.Optimum filter for colored noise. The A Posteriori Theory of Reception. Statistical theory of detection. Detection based on a single sample. Detection based on multiple samples. Estimation of signal parameters.			
Practical teaching (exercises, OFE, study and research work)	Lectures. Consultations. Study and research work.			
Textbooks/references				
1	V. N. Vapnik, Statistical Learning Theory (detection and estimation), Wiley-Interscience, 1998.			
2	J. Proakis, M. Salehi, Digital Communications, McGraw-Hill Education, 5th edition, 2007.			
3	U.Spagnolini, Statistical Signal Processing in Engineering, Wiley, 2018.			
4	A. R. Webb, K. D. Copsey, Statistical Pattern Recognition, Wiley, 3rd Edition, 2011.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, Project work, Consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Communication Algorithms and Applications		
Lecturer (for lectures)		Panajotović S. Aleksandra		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquire knowledge required for implementation of the most important communication algorithms and procedures used in the detection and synhronization, in both software and hardware implementation.			
Course outcomes	The student is able to independently design, analyze, and develop algorithms for adaptive signal processing, equalization, and synchronization, implement them, and critically evaluate and improve existing algorithmic solutions.			
Course outline				
Theoretical teaching	Linear prediction and the Wiener filter. Adaptive transversal filters. LMS, RLS algorithms and their variations. Adaptive algorithm for channel equalization. Algorithms for synchronizations. Fundamental algorithms for frequency synchronization. Fundamental algorithms for time synchronization. Fundamental algorithms for synchronization of PN sequence. Implementation of communication algorithms. The application of communication algorithms in DSP, FPGA ans ASIC circuits.			
Practical teaching (exercises, OFE, study and research work)	Definition of a project/research task, analysis and discussion of relevant scientific and professional literature, and independent student work on the assigned project/research task. Dissemination of the project/research results through the preparation of a scientific paper presented at a conference or published in a journal, or through a written report and an oral presentation of the results followed by discussion.			
Textbooks/references				
1	N. Benvenuto, G. Cherubini, S. Tomasin, Algorithms for Communications Systems and Their Applications, Wiley, 2nd edition, 2021.			
2	K. Yao, Signal Processing Algorithms for Communication and Radar Systems, Cambridge University Press, 2019.			
3	K. S. Mohamed, Wireless Communications Systems Architecture: Transceiver Design and DSP Towards 6G, Springer, 2022.			
4	T. P. Zielinski, Starting Digital Signal Processing in Telecommunication Engineering, Springer, 2021.			
5	Collection of selected scientific papers.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, consultations, students' work on the project (project presentation with discussion)			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		5G and 6G Mobile Communications		
Lecturer (for lectures)		Milošević D. Nenad		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Enabling students for independent, original scientific research in the field of fifth and sixth-generation mobile communications. Developing competencies for the critical evaluation of advanced network architectures, as well as for the conception, design, and development of new methods, protocols, and algorithms based on software-defined networks, network function virtualization, and cognitive approaches.			
Course outcomes	Upon successful completion of the course, the student is qualified to independently formulate research hypotheses and conceive original solutions in the domain of 5G and 6G mobile networks. The student acquires the ability to critically evaluate current scientific paradigms related to massive MIMO processing, SDN, and NFV technologies, as well as to design new models for optimizing spectral efficiency, latency, and energy consumption. Additionally, the student is trained to apply sophisticated research methods for quantitative network performance analysis, validate the obtained results through simulation models, and formulate scientific research conclusions ready for publication in peer-reviewed/reference scientific journals.			
Course outline				
Theoretical teaching	Introduction to open research problems in fifth and sixth-generation mobile communications. Critical analysis of technological advancements and key implementation challenges. Structure and components of 5G and 6G networks. Advanced research in the domains of frequency bands, millimeter waves, and massive MIMO system technologies. Network protocols and virtualization: a critical review of advanced network virtualization techniques, software-defined networks, and network function virtualization. Development of new models for capacity and efficiency optimization: spectral efficiency, ultra-low latency, and energy resource management in new generations of communications. Security challenges: risk evaluation and development of advanced security measures in 5G and 6G architectures.			
Practical teaching (exercises, OFE, study and research work)	Scientific research work is conducted through the realization of an independent scientific research project in the field of mobile telecommunications. The research process begins with a systematic literature review in reference scientific databases to identify research gaps and precisely define the research problem. The student then defines a research methodology that encompasses the design and execution of research through the development of analytical models and advanced network simulations. For the performance evaluation of new 5G and 6G concepts, appropriate system-level or network-level software simulators are used. The next step involves data processing and a comparative quantitative analysis of the obtained results against existing solutions from current scientific papers, along with a critical interpretation of the impact of the proposed mechanisms on network capacity, delay, or reliability. The final expected scientific research outcome is the synthesis of results through writing an original scientific paper proposal structured according to the standards of leading international conferences or journals.			
Textbooks/references				
	1	S. Glisic, Advanced wireless networks: technology and business models, Wiley, 2016		
	2	G. Stüber, Principles of Mobile Communication, Springer International Publishing, 2017		
	3	Y. Zaki, Future Mobile Communications: LTE Optimization and Mobile Network Virtualization, Vieweg+Teubner Verlag, 2013		
	4	P. Ahokangas, A. Aagaard, The Changing World of Mobile Communications: 5G, 6G and the Future of Digital Services, Springer, 2024		
	5	M. Božanić, S. Sinha, Mobile Communication Networks: 5G and a Vision of 6G, Springer, 2021.		
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0

Teaching methods	Interactive theoretical teaching with a mentoring approach and critical discussion of current scientific paradigms. Scientific research work that includes systematic searching and critical evaluation of reference scientific databases with the aim of identifying open problems and defining research hypotheses. Independent realization of research through the development of analytical and simulation models, comparative quantitative processing, and interpretation of the obtained data. Individual consultations and public presentation of research results in the form of an original scientific paper or project proposal.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Information Theory and Source Coding		
Lecturer (for lectures)		Perić H. Zoran, Jovanović Ž. Aleksandra		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Dissemination of knowledge and familiarization with the latest achievements and research in the fields of information theory and source coding.			
Course outcomes	The student will acquire knowledge that will enable them to follow professional literature and engage in scientific research in the field of information theory and source coding.			
Course outline				
Theoretical teaching	Shannon entropy and differential entropy. Other measures of information and entropy. Markov chains and hidden Markov models. Rate-distortion theory. Source coding with fixed-length codewords. Source coding with variable-length codewords. Source coding based on robust quantizers. Adaptive source coding for non-stationary or highly variable signals. Lifting-based coding algorithm using wavelet transforms. Adaptive modulation and coding.			
Practical teaching (exercises, OFE, study and research work)	Project assignments.			
Textbooks/references				
1	T. M. Cover, J. A. Thomas, Elements of Information Theory, Wiley-Interscience, 2006.			
2	A. Gersho, R. M. Gray, Vector Quantization and Signal Compression, Kluwer Academic Publishers, 1992.			
3	K. Sayood, Introduction to Data Compression, Elsevier, Morgan Kaufmann; 5th edition, 2018.			
4	D. Salomon, Data Compression: The Complete Reference, Springer, 2007.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures. Consultations. Scientific research.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures		10	Written exam	
Exercises			Oral exam	40
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Statistical Signal Processing		
Lecturer (for lectures)		Đorđević T. Goran		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives		Deepening knowledge in the area of signal detection over channels with intersymbol interference, iterative decoding, and simulation of telecommunication systems.		
Course outcomes		Students will be trained to conduct research in the field of optimal receivers in systems with intersymbol interference. They will acquire the necessary knowledge to model and simulate telecommunication systems with the aim of evaluating and improving their performance.		
Course outline				
Theoretical teaching		Random signals. Systems for adaptive processing of random signals. Adaptation algorithms. System identification. Prediction. Adaptive interference suppression. Optimal receivers for systems with intersymbol interference. Equalization methods: linear equalization, decision feedback equalization, iterative equalization. Adaptive linear equalization. Adaptive decision feedback equalization. Recursive algorithms for adaptive equalization based on the least squares method. Application of the Viterbi algorithm to equalization. Iterative decoding. BCJR (Bahl-Cocke-Jelinek-Raviv) algorithm. Monte Carlo simulations and the importance sampling method. Software implementation in MATLAB.		
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	J. G. Proakis, M. Salehi, Digital Communications, 5th edition, McGraw-Hill, New York, USA, 2007.			
2	J. G. Proakis, Manolakis, Digital Signal Processing, 4th edition, 2007.			
3	S. Esakkirajan, T. Veerakumar, B. N. Subudhi, Digital Signal Processing: Illustration using Python, 1st ed. Springer, 2024.			
4	S. Haykin, Adaptive Filter Theory, 4th edition, Prentice Hall, NJ, USA, 2002.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods		Lectures. Consultations. Seminar. Preparation and oral presentation of a seminar paper.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures		10	Written exam	
Exercises			Oral exam	
Colloquia				50
Projects		40		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Communications Over Fading Channel		
Lecturer (for lectures)		Milović M. Daniela		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites		None		
Course objectives	The objective of this course is to provide doctoral students with an advanced theoretical and analytical framework for the study of digital communications over fading channels. The course aims to develop students' ability to independently analyze and model complex fading phenomena, critically evaluate existing diversity and combining techniques, and apply rigorous mathematical methods to assess system performance. Students will be prepared to identify open research problems in the field of wireless communications, propose original solutions, and contribute to the advancement of knowledge in areas such as MIMO systems, optimal receiver design, and fading channel mitigation strategies.			
Course outcomes	Upon completion of this course, students will be able to: analyze and evaluate mathematical models of fading channels, including multipath, log-normal shadowing, and frequency-selective fading; Independently apply and compare diversity combining techniques (EGC, MRC, SC, GSC, T-GSC) and assess their performance limits; Design and implement simulation models for wireless systems over fading channels and interpret results in the context of current research; Critically evaluate published scientific results in the field of digital communications over fading channels; Develop original approaches to performance analysis of MIMO systems and propose improvements to existing solutions.			
Course outline				
Theoretical teaching	Characterization and modeling of fading channels, including multipath fading and log-normal shadowing. Analysis of frequency-selective and nonselective fading, as well as flat fading channel models. Coherent detection and optimal receivers for fading environments. Diversity techniques such as EGC, MRC, SC, GSC, and T-GSC. MIMO communication systems and optimum signal combining for improved performance.			
Practical teaching (exercises, OFE, study and research work)	MATLAB/Python simulation of Rayleigh and Ricean fading channel models; Numerical evaluation of BER performance for BPSK/QPSK modulation under flat and frequency-selective fading; Implementation and comparison of diversity combining algorithms (MRC, SC, EGC); Simulation of MIMO systems with different antenna configurations and analysis of capacity gains; Critical review and presentation of selected recent research papers on fading channel mitigation techniques.			
Textbooks/ref				
	1	Marvin K. Simon, Mohamed-Slim Alouini, Digital Communications over Fading Channels, Wiley, 2nd Ed., 2005.		
	2	A. Papoulis, S. U. Pillai, Probability, Random Variables and Stochastic Processes, McGraw-Hill, 4th Ed., 2002.		
	3	D. Tse, P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.		
	4	E. Biglieri et al., MIMO Wireless Communications, Cambridge University Press, 2007.		
	5			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, auditory exercises, homeworks, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Coherent Optical Telecommunication Systems		
Lecturer (for lectures)		Milić N. Dejan		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Students will be introduced to details about coherent systems in modern optical telecommunications and to the critical review of the methods used in analysis of such systems.			
Course outcomes	Acquired knowledge enables understandig of the modern trends in optical communications, provides a background for estimating a practical usability of such trends, and introduces the students to academic research in the field of optical communications.			
Course outline				
Theoretical teaching	Coherent detection in optical communications. Differences between IM/DD and coherent systems. Modulation formats. Generation of RZ-DPSK signals. Homodyne and heterodyne detection. Balanced detection. Quadrature receivers. Synchronous and asynchronous demodulation. Interferometric detection. Phase noise. Phase and polarization diversity. Polarization modulation. Multiplexing of optical signals. TDM, FDM, WDM, SCM, CDMA. Polarization multiplexing. Cross-phase modulation. Spectral efficiency of IM/DD and coherent channels. Quantum capacity limits.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	G. Agrawal, Lightwave Technology: Telecommunication Systems, John Wiley & Sons, 2005			
2	G. Jacobsen, Noise in Digital Optical Transmission Systems, The Artech House Library, London, 1994			
3	G. Agrawal, Fiber Optic Communications Systems, John Willey & Sons, 2002			
4	K. Iizuka, Elements of Photonics, Volume II, , John Wiley & Sons 2002			
5	A. Papoulis, Probability, Random Variables and Stochastic Processes, McGraw Hill, 1991			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Theory classes, consulatations, study and research work.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Theory and Applications of Software Radio		
Lecturer (for lectures)		Milošević D. Nenad		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Enabling students for independent, original scientific research in the field of software-defined radio (SDR) and cognitive radio networks. Developing competencies for the critical evaluation of existing transceiver architectures and algorithms, as well as for the conception, design, and development of new original solutions and methods in the design of modern communication systems based on software-defined radio.			
Course outcomes	Upon successful completion of the course, the student is qualified to critically analyze and evaluate the latest scientific achievements and current scientific paradigms in the field of software-defined radio, to independently formulate research hypotheses and design experimental and simulation models for the development and testing of new algorithms (for smart antennas, digital signal processing, or cognitive networking), to develop and implement original software and hardware solutions aimed at improving the performance of SDR transceivers, and to conduct advanced quantitative analysis and interpretation of research results, clearly articulating them in the form of a scientific research paper ready for publication in peer-reviewed/reference scientific journals or at international conferences.			
Course outline				
Theoretical teaching	Evolution of radio technology. Transceiver architectures. Antennas and receiver front-end. Multi-rate digital signal processing. Direct digital synthesis (DDS). Analog-to-digital and digital-to-analog conversion. Introduction to smart antennas, signal processing algorithms in the baseband. Antenna arrays and beamforming. Digital hardware for software-defined radio. Software methods for software-defined radio. Cognitive networking. Critical review of the latest scientific achievements and open research problems in SDR system design.			
Practical teaching (exercises, OFE, study and research work)	Scientific research work is conducted through an independent project and encompasses the following phases: 1. Search Methodology: Conducting a systematic literature review in reference scientific databases (IEEE Xplore, Web of Science, Scopus) to identify open research problems and define the direction of one's own research, 2. Research Methods: Design and execution of research using advanced numerical simulation methods (e.g., using MATLAB/Simulink, GNU Radio environments) and/or experimental measurements on hardware SDR platforms (e.g., USRP). The research includes the development and testing of new algorithms for signal processing or cognitive spectrum access, 3. Results Analysis: Quantitative analysis of the obtained results (e.g., analysis of spectral efficiency, BER performance, latency) and their critical comparative evaluation against existing state-of-the-art solutions from current scientific papers, 4. Research Outcome: Synthesis of research results and writing a scientific paper proposal in which the student defends the originality and contribution of the proposed solution.			
Textbooks/references				
1	J. Mitola III, Software Radio Architecture, John Wiley & Sons, 2000.			
2	T. Collins, R. Getz, Di Pu, A. Wyglinski, Software-Defined Radio for Engineers, Artech House Publishers, 2018.			
3	J. M. Reyland, Software Defined Radio: Theory and Practice, Artech House, 2023.			
4	Di Pu, A. Wyglinski, Digital Communication Systems Engineering with Software-Defined Radio, Artech House, 2013.			
5	J. H. Reed, Software Radio: A Modern Approach to Radio Engineering, Prentice Hall PTR, 2002.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0

Teaching methods	Interactive theoretical teaching with a mentoring approach and critical discussion of current scientific paradigms. Scientific research work that includes systematic searching and critical evaluation of reference scientific databases with the aim of identifying open problems and defining research hypotheses. Independent realization of research through the development of analytical and simulation models, comparative quantitative processing, and interpretation of the obtained data. Individual consultations and public presentation of research results in the form of an original scientific paper or project proposal.		
Grade (maximum number of points 100)			
Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Modeling Techniques for RF Applications		
Lecturer (for lectures)		Dončov S. Nebojša, Pronić-Rančić R. Olivera, Joković J. Jugoslav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Development of competencies for the critical analysis, modelling and optimization of RF and microwave components, circuits and systems through the application of modern analytical, numerical, optimization and ML methods. Training the student for independent scientific research work in the field of advanced modelling for RF applications.			
Course outcomes	Upon successful completion of the course, the student is able to critically analyse recent scientific results in the field of modelling RF and microwave components, circuits and systems, formulate a research problem and select an appropriate approach for solving it. The student acquires the ability to develop, improve and verify models of components, assemblies or parameters of selected RF communication systems, as well as to critically interpret the results and present them in the form of a research report or scientific paper.			
Course outline				
Theoretical teaching	Theoretical aspects of modeling procedures as a key element in RF circuit and system design. Overview of the most frequently used modeling techniques for RF applications. Introduction to selected modeling techniques. Optimization techniques. Evolutionary algorithms. Application of machine learning methods for modeling in RF and microwave communications. Examples of component and assembly modeling for RF and microwave communications. Development, verification and critical analysis of models in the selected areas.			
Practical teaching (exercises, OFE, study and research work)	The study research work includes a systematic analysis of recent scientific literature in the field of advanced modelling for RF applications, identification of a research problem, formulation of research questions and selection of an appropriate modelling approach. Within the research work, the student develops or modifies a model of an RF/microwave component, assembly, system or its selected parameter, and performs simulations, optimization and/or model validation. Special emphasis is placed on the analysis of the accuracy and limitations of the proposed model, comparison of results with measurements, reference models or results from recent literature, as well as on the critical interpretation of results and preparation and presentation of a research report or scientific paper.			
Textbooks/references				
1	George D. Vendelin, Anthony M. Pavo, Ulrich L. Rohde, Matthias Rudolph: Microwave Circuit Design Using Linear and Nonlinear Techniques ,3rd Edition, John Wiley & Sons, 2021			
2	Q. J. Zhang, K. C. Gupta, Neural Networks for RF and Microwave Design, Artech House, 2000.			
3	Scientific publications in a selected area.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Presentations on selected topics, analysis of selected scientific papers, project-based independent research work, consultations, discussion of results, critical analysis of proposed models and methods, preparation and defence of a seminar/research paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Free-space Optical Telecommunications		
Lecturer (for lectures)		Milić N. Dejan, Milović M. Daniela		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Students will be introduced to details about free-space optical systems in modern optical telecommunications and to the critical review of the methods used in analysis of such systems.			
Course outcomes	Acquired knowledge enables understanding of the modern trends in free-space optical communications, provides a background for estimating a practical usability of such trends, and introduces the students to academic research in the field of optical wireless communications.			
Course outline				
Theoretical teaching	Basics of free-space optical telecommunication technologies. Integration of FSO in optical networks. Long range communications, satellite optical communications. Optical wireless technologies in closed spaces. Coherent and incoherent detection. Characteristics, modulation techniques and propagation effects. Optical components for FSO. Signal processing in optical an electrical domain. Diversity reception with different combining strategies.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	W. Heinz, Free Space Optics, Sams, 2001.			
2	S. Hranilović, Wireless Optical Communication Systems, New age publishers, 2006			
3	M. Katzman, Laser Satellite Communication, Prentice Hall, New York, 1991			
4	K. Iizuka, Elements of Photonics, Volume II, , John Wiley & Sons 2002			
5	A. Papoulis, Probability, Random Variables and Stochastic Processes, McGraw Hill, 1991			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Theory classes, consultations, study and research work.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Artificial Neural Networks - Chosen Chapters		
Lecturer (for lectures)		Perić H. Zoran, Nikolić R. Jelena		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	To provide knowledge in the field of artificial neural networks and to enable students to write a scientific research paper in this highly relevant area of research.			
Course outcomes	Students will be able to understand the challenges involved in training neural networks and in inference. With mentoring, they will be able to make research advancements in this field.			
Course outline				
Theoretical teaching	Signal parameter estimation. Statistical learning. Adaptive signal processing. Training of artificial neural networks. Spike neural networks. Hybrid neural networks. Neural network compression techniques. Pruning techniques.			
Practical teaching (exercises, OFE, study and research work)	Lectures. Consultations. Research study work.			
Textbooks/references				
1	F. Chollet, Deep Learning with Python, 2nd Edition, MANNING PUBLICATIONS, 2021.			
2	I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2016.			
3	C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2007.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures, PowerPoint presentations, consultations.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	5	Written exam		
Exercises	30	Oral exam		35
Colloquia				
Projects	30			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Systems Theory		
Lecturer (for lectures)		Antić S. Dragan, Mitić B. Darko, Milovanović B. Miroslav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Mastering the control system theory content. Training the students for active literature following up and analyzing, as well as for scientific research in the different fields of control systems theory.			
Course outcomes	Ability of critical analysis of existing solutions and finding original solutions on selected topics in the control systems theory.			
Course outline				
Theoretical teaching	System definition, examples, history, importance and classification of control systems. The basic principles of control. Mathematical description of dynamical systems. A uniform approach to system analysis. Basic system performances. System stability analysis. Technical requirements specification and principles of control system design. Performance evaluation. Some engineering problems. MATLAB implementations.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	G. C. Goodwin, S. F. Graebe , and M. E. Salgado, Control System Design, Prentice-Hall, 2000.			
2	R.C. Dorf, and R.H. Bishop, Modern Control Systems, Prentice-Hall, 2004.			
3	W. S. Levine, The Control Handbook, CRC Press, 1996.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures / consultation (in accordance with the number of students); scientific research (review of the literature, concrete problem analysis and finding solution, writing and presentation of individual paper).			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		System Identification		
Lecturer (for lectures)		Nikolić S. Saša, Danković B. Nikola		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Gaining knowledge about modern system identification methods, iterative identification methods and getting acquainted with modern computer systems and identification software.			
Course outcomes	Knowledge of the application of modern computer systems and identification software in practice, as well as the application of identification in adaptively controlled systems.			
Course outline				
Theoretical teaching	Identification facilities and their classification. Identification algorithms. Convergence to identification algorithms. Active identification. Gradient identification method. One-dimensional and multi-dimensional regression models. Nonlinear regression method. Iterative identification methods. Passive identification methods. Planning the experiment. Parametric representation of a black-box system model. Non-parametric representation of a black-box system model. Methods for assessing the quality of identification. System dynamics recognition using visual analysis and semi-automatic identification. System identification using AutoML tools without programming. Data-based system identification. Identification in conditions of limited data quantity and quality. Modern cloud and edge platforms for identification in industry.			
Practical teaching (exercises, OFE, study and research work)	Introduction to MATLAB System Identification Toolbox and its application in identification of a real dynamic system. Application of orthogonal rational functions and orthogonal filters in system identification. Applying the acquired knowledge in identifying the following systems: The liquid flow control system G.U.N.T. Flow Control Trainer RT522, Liquid Level Management System G.U.N.T. Level Control Trainer RT512, Pressure regulating system G.U.N.T. Pressure control trainer RT532, Temperature control system G.U.N.T. Temperature control trainer RT542. Visual identification of the system dynamics in Matlab Gui environment. Application AutoML and Drag-and-Drop Identification tools.			
Textbooks/references				
1	P. Albertos, A. Sala, "Iterative Identification and Control", Springer, 2002.			
2	Van Hee, K., van der Aalst, W. (2022). Process Mining: Data Science in Action (2nd ed.), Springer.			
3	B. Codrons, "Process Modelling for Control-A Unified Framework Using Standard Black-box Techniques", Springer, 2006.			
4	MATLAB 2023, System Identification Toolbox.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Forms of teaching (classical - lectures or mentoring - consultations) according to the number of students. With the help of scientific journals and other literature, the student deepens the material from the lectures, and through consultations and study research work with the teacher, the student is trained to independently write a scientific paper. The student is required to independently complete the project.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Robust Control		
Lecturer (for lectures)		Veselić R. Boban, Mitić B. Darko, Danković B. Nikola		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Introduction to the problems of model uncertainties and modeling errors, robust stability principles as well as control systems design methods for providing robust stability and robust performance.			
Course outcomes	Students possess the theoretical knowledge required for the design of robust control systems under model uncertainties and specified system performance requirements. They are capable of following contemporary scientific literature and critically analyzing emerging solutions and methodologies, thereby strengthening their competencies for independent research and contributions to the field. Furthermore, they are trained to effectively utilize computer-aided tools and laboratory equipment in the analysis and synthesis of robust control systems.			
Course outline				
Theoretical teaching	Model uncertainties of linear dynamical systems and their representation in time and frequency domain. H_2 and H_∞ spaces and norms. Specifications of performances and limitations. Control plant model reduction. Model uncertainties and robustness. Robust stability and performance analysis. Linear fractional transformations. Structured singular value. Controller parameterization. Algebraic Riccati equation. H_2 и H_∞ control. Controller order reduction. H_∞ loop-shaping.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1 K. Zhou, J. Doyle, Essentials of Robust Control, Prentice-Hall, 1998.				
2 S. Skogestad, I. Postlethwaite, Multivariable Feedback Control, John Wiley & Sons,1996.				
3 Kang-Zhi Liu, Yu Yao, Robust Control: Theory and Applications, John Wiley & Sons, 2016.				
4 Luigi Fortuna, Mattia Frasca, Arturo Buscarino, Optimal and Robust Control (2nd Edition), CRC Press / Taylor & Francis, 2021.				
5 Ben M. Chen, Robust and H_∞ Control, Springer London, 2000.				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (depending on the number of students); Part of the course is conducted through individual research and scientific work in the area of robust control. Research activities include the critical study of relevant scientific literature, numerical simulations, and conducting of robust control experiments on different control plants using the dSPACE development environment. This should result in writing and presenting a scientific paper.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	0	Written exam		0
Exercises	0	Oral exam		50
Colloquia	0			
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Computer Controlled Systems		
Lecturer (for lectures)		Jovanović D. Zoran, Spasić D. Miodrag		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Acquiring additional knowledge about methods of complex technological processes, centralized, distributed and hierarchical control. Study research work, preparation of professional and scientific work, as well as development of projects.			
Course outcomes	Gaining knowledge about the application of computer systems in the design and implementation of control systems in the process industry, control of distributed control systems and complex dislocated systems.			
Course outline				
Theoretical teaching	Problems of complex technological processes control. Centralized control. Distributed control. Hierarchical control. Computer configuration for real-time control. Input-output devices. Program support for real-time system control. Coupling computers with technological processes. Application of microcomputers in the design and implementation of control systems. Application of PLC and SCADA systems in process control. Application of computers in the process industry, in the control of dislocated facilities and in the control of utility systems.			
Practical teaching (exercises, OFE, study and research work)	Acquiring methodological units of theoretical teaching through the development of seminars and projects.			
Textbooks/references				
1	G. Olsson, G. Piani, "Computer Systems for Automation and Control", Prentice Hall, 1992.			
2	K. Erickson, J. Hedrick, "Plantwide Process Control", John Wiley and Sons, 1999.			
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Forms of teaching (classical – lectures or mentoring – consultations) depend on the number of students. Using scientific journals and other literature, the student deepens the material covered in lectures, while through consultations and research work with the instructor, the student is trained to independently write a scientific paper. The student is required to complete a project independently.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Robotics and Automation		
Lecturer (for lectures)		Raković M. Mirko, Nikolić N. Milutin		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Understanding the specificities, justification, and necessity of automated production. Familiarization with the basic components of automation. Using a robot as a universal machine. Application of robots in an industrial environment. Application of robots in a human environment.			
Course outcomes	Analyzes basic production strategies and evaluates their impact on the productivity and flexibility of production systems. Identifies the specific requirements and justification for applying robots in structured industrial plants, as well as in unstructured environments and human surroundings. Selects appropriate robot constructions, end effectors, and sensor systems in accordance with the technological requirements of automation. Explains the operating principles of vision and perception systems, and applies the concepts of robotic autonomy in motion planning. Develops software solutions for programming and controlling the motion of robotic systems. Programs and configures programmable logic controllers (PLCs) and integrates standard industrial interfaces. Independently designs flexible manufacturing cells by integrating robots, transport systems, and PLCs into a unified, functional automated system.			
Course outline				
Theoretical teaching	Production system. Basic production strategies. Productivity and flexibility in production. Unstructured environments as a motive for robot application. Robots in production and non-production environments. Basic types of robot constructions. Robot sensors. Robot end effectors. Motion control and robot programming. Vision and perception systems. Robot programming. Robotic autonomy and planning. Transport systems. Programmable logic controllers. Industrial interfaces. Formation of a flexible manufacturing cell.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	S.M. LaValle, Planning Algorithms, Cambridge University Press, 2006, ISBN: 0521862051			
2	S. Thrun, W. Burgard, D. Fox, Probabilistic Robotics, The MIT Press, 2005, ISBN: 0262201623			
3	B. Siciliano, O. Khatib, Springer Handbook of Robotics, Springer, 2016, ISBN: 978-3319325507			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Multimedia and interactive lectures; consultative teaching			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Intelligent Control		
Lecturer (for lectures)		Milojković T. Marko, Milovanović B. Miroslav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The primary objective of this course is to equip students with advanced knowledge and skills oriented towards research in the field of intelligent control systems. The course explores the integration of artificial intelligence techniques with classical control theory in order to design robust, adaptive and autonomous systems capable of operating in complex, nonlinear and uncertain environments. The emphasis is on theoretical foundations and practical implementation, with the aim of preparing students to contribute to cutting-edge research and real-world applications in areas such as robotics, autonomous systems, process control and cyber-physical systems.			
Course outcomes	Mastering algorithms of intelligent systems for classification and optimization of databases, different types of neural network training, practical implementation of neural networks for various control tasks, principles of unsupervised learning and design of models of intelligent systems with unsupervised learning, methods for implementing algorithms of Recommender systems, techniques for implementing intelligent systems and their algorithms when the task is to work with large data sets (Large Scale Machine Learning), use of ANFIS in control logics of dynamic systems.			
Course outline				
Theoretical teaching	Introduction to intelligent control, Comparison with conventional control approaches, Fuzzy logic-based control, Neural network-based control, Evolutionary and swarm-based methods, Reinforced learning and adaptive critical designs, Hybrid intelligent control systems, Intelligent control of nonlinear and complex systems, Real-time implementation and applications, Latest trends in intelligent control.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	M. Schoen, "Introduction to Intelligent Systems, Control, and Machine Learning using MATLAB", Cambridge University Press, 2023.			
2	H. Nguyen, N. Prasad, "A First Course in Fuzzy and Neural Control", Chapman & Hall, 2003.			
3	L. Chambers, "The Practical Handbook of Genetic Algorithms", Chapman & Hall, 2001.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (according to the number of students); study research work (inspection of literature, analysis of problems, finding solutions, writing and presentation of independent work).			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Advanced Mechatronics		
Lecturer (for lectures)		Perić Lj. Staniša		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The aim of the course is to acquire advanced knowledge and skills in the field of modern mechatronic systems through the integration of modeling, control, and intelligent technologies. Students are trained to analyze, design, and research complex mechatronic systems, applying modern methods and critically evaluating current research directions.			
Course outcomes	The student will be able to apply advanced modeling and control methods to mechatronic systems, use artificial intelligence in technical applications, integrate complex components into modern systems, and independently solve research problems in the field of mechatronics.			
Course outline				
Theoretical teaching	Advanced modeling techniques for mechatronic systems. Hybrid and nonlinear dynamic systems. Simulation and integration of software tools. Embedded systems and real-time control. Data fusion and fault tolerance. Machine learning in mechatronics. Reinforcement learning in the control of mechatronic systems. Application of neural networks in diagnostics and adaptation. Multi-objective optimization in system design. Distributed and networked mechatronic systems. Communication protocols and cybersecurity. Collaborative robots and human–machine interaction. Smart materials and next-generation actuators.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Dan Zhang, "Advanced Mechatronics and MEMS Devices", Springer New York, 2013.			
2	Maki K. Habib, "Handbook of Research on Advanced Mechatronic Systems and Intelligent Robotics", IGI Global, 2019.			
3	Ryszard Jabłoński, Tomas Brezina, ""Advanced Mechatronics Solutions"", Springer International Publishing, 2015.			
4	Clarence W. De Silva, "Mechatronics: An Integrated Approach", CRC Press, 2005.			
5	Sabri Cetinkunt, "Mechatronics", John Wiley & Sons Inc., 2007.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (depending on the number of students); study-research work (literature review, problem analysis, finding solutions, writing and presenting an independent paper).			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Digital Control Techniques		
Lecturer (for lectures)		Veselić R. Boban		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	Mastering the content that is related to the techniques of digital control. Training the students for active literature monitoring and scientific research in the field of digital control systems.			
Course outcomes	Ability of critical analysis of existing solutions and finding original solutions on selected topics in the theory of digital control systems.			
Course outline				
Theoretical teaching	Modern theory of digital control systems. Discretization process in digital signal processing theory and digital control theory. Discretization methods of continuous dynamic control systems and their properties. Unified approach to the analysis and synthesis of digital control systems. Elements of analysis and synthesis of nonlinear digital control systems. Hardware and software implementation of digital control algorithms.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	R. H. Middleton, G.C. Goodwin, Digital Control and Estimation: A Unified Approach, Englewood Cliffs, N.J.: Prentice-Hall, 1990.			
2	A. Feuer and G. C. Goodwin, Sampling in Digital Signal Processing and Control, Boston: Birkhäuser, 1996.			
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (depending on the number of students); study and research work (insight into literature, problem analysis, finding solutions, writing and presentations of individual paper)			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures	0	Written exam		0
Exercises	0	Oral exam		50
Colloquia	0			
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Optimal Control		
Lecturer (for lectures)		Antić S. Dragan, Veselić R. Boban, Spasić D. Miodrag		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		12	Course status (obligatory/elective)	Elective
Prerequisites	None			
Course objectives	To obtain knowledge about modern methods in optimal control of industrial systems as well as optimal control in digital systems.			
Course outcomes	Students have acquired knowledge of the design of optimal controllers and their application in industry and distributed systems, as well as knowledge of the formulation of optimal control strategies and their application in the control of complex and hierarchical systems. Students are capable of following contemporary scientific literature and analyzing new solutions and methods, thereby strengthening their competencies for independent scientific work and contributions in the field. They are also trained in the use of computer-based tools and other laboratory equipment in the process of analysis and synthesis of optimal control systems.			
Course outline				
Theoretical teaching	Calculus of variations. Maximum principle. Normal and singular problem of optimal control. Structure and design of optimal controllers. Selected topics in dynamical systems optimization. Dynamic programming. Hamilton-Jacobi-Bellman differential equation. Optimal solution as a function of the state vector. Singular control in some linear systems with quadratic cost function. Optimal control in digital systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
	1	D. Naidu, "Optimal Control Systems", CRC Press, 2003.		
	2	C. MacCluer, "Calculus of Variations", Prentice Hall, 2005.		
	3	Luigi Fortuna, Mattia Frasca, Arturo Buscarino, Optimal and Robust Control (2nd Edition), CRC Press / Taylor & Francis, 2021.		
	4	Frank L. Lewis, Draguna Vrabie, Vassilis L. Syrmos, Optimal Control (3rd Edition), John Wiley & Sons, 2012.		
	5			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (depending on the number of students). A portion of the course is implemented through individual research activities and scientific work in the field of optimal control. The research component is based on the analysis of the given problem, active study of relevant scientific sources, numerical simulations of the proposed solution, and the organization and implementation of optimal control experiments on a specific system using the dSPACE development environment. This activity should result in the preparation and presentation of a scientific paper.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Variable Structure Systems		
Lecturer (for lectures)		Antić S. Dragan, Mitić B. Darko, Spasić D. Miodrag		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Gaining knowledge of the variable structure control systems with sliding mode and their application in the control of continuous- and discrete-time systems.			
Course outcomes	Independent generation of original hypotheses and advanced continuous-time and discrete-time sliding mode controls for complex systems. Critical analysis and evaluation of existing scientific results and their limitations. Design of innovative methodological solutions for chattering alleviation in multivariable systems. Conceptualization of advanced vector and robust control algorithms based on plant input/output measurements. Autonomous application of theoretical concepts to real engineering problems and validation of solutions through high-impact scientific publications.			
Course outline				
Theoretical teaching	The concept of variable structure systems and sliding mode. Continuous- and discrete-time sliding modes. Quasi sliding modes. Characteristics of systems with sliding mode control. Invariance conditions. Problems of mathematical description of sliding mode. Filippov's method. Equivalent control method. Stability of the systems with the sliding mode control. Systems with scalar and vector control. Methods for realization of sliding mode control in multivariable systems. Chattering reduction. Problems of realization of systems with sliding mode control. Sliding mode control in systems with finite zeros. Realization of sliding mode control based only on measuring of plant inputs and outputs. Examples of practical implementation of sliding mode control.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	V.Utkin, J.Guldner, J.Shi, "Sliding Mode Control in Electromechanical System", CRC Press, 1999.			
2	W. Perruquetti, J. P. Barbot, "Sliding mode control in engineering", Marcel Dekker, 2002.			
3	Y. Shtessel, C. Edwards, L. Fridman, A. Levant, " Sliding Mode Control and Observation", Springer, 2014.			
4	R. K. Moghaddam, M. Rabbani, "Methods of Developing Sliding Mode Controllers: Design and Matlab Simulation", John Wiley & Sons, 2025.			
5	T. R. Oliveira, L. Fridman, L. Hsu (Eds.), "Sliding-Mode Control and Variable-Structure Systems: The State of the Art", Springer, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (in accordance with the number of students); study research work (review of the literature, analysis of problems, finding solutions, writing and presentation of individual work).			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Distributed Computer Control		
Lecturer (for lectures)		Jovanović D. Zoran, Danković B. Nikola		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	Gaining additional knowledge about distributed control systems, communication networks, and control algorithms for distributed systems.			
Course outcomes	At the end of the course, the student is able to independently identify, formulate and solve complex scientific problems in the field of distributed control systems, developing new methods and solutions.			
Course outline				
Theoretical teaching	Problems of controlling complex technological processes. Centralized control. Distributed control. Hierarchical control. Selection of computers for real-time control. Input-output devices. Program support for real-time control of systems. Coupling computers with technological processes. Application of microcomputers in the design and implementation of control systems. Application of PLC and SCADA systems in process control. Application of computers in the process industry, in the control of dislocated objects and in the control of utility systems. Trends in distributed computer control.			
Practical teaching (exercises, OFE, study and research work)	Mastering methodological units of theoretical teaching through the preparation of seminars, projects and scientific papers. Independent systematic analysis of current scientific literature in the field of distributed computer control systems. Mathematical modeling and simulation of distributed systems, performance analysis of communication protocols, experimental validation of control algorithms in laboratory settings or software simulators. Comparative analysis of the obtained results with the current state of science.			
Textbooks/references				
1	G. Ellis, "Control System Design Guide", Elsevier, 2012.			
2	K. Erickson, J. Hedrick, "Plantwide Process Control", John Wiley and Sons, 1999.			
3	V. Bhatkar, "Distributed Computer Control Systems in Industrial Automation", CRC Press, 2017.			
4	M. P. Groover, "Automation, Production Systems, and Computer-integrated Manufacturing", Prentice Hall, 2008.			
5	M. Hamzah, M.M. Islam, S. Hassan, M.N. Akhtar, M.J. Ferdous, M.B. Jasser, A.W. Mohamed, "Distributed Control of Cyber Physical System on Various Domains: A Critical Review", Systems, vol. 11, no. 4, 208, 2023.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Forms of teaching (classical - lectures or mentorship - consultations) according to the number of students. With the help of scientific journals and other literature, the student deepens the teaching material, and through consultations and study research work with the teacher, the student is trained for independent writing scientific work. The student is obligated to do the project independently.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				
Projects	50			

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Predictive Control		
Lecturer (for lectures)		Mitić B. Darko, Nikolić S. Saša, Spasić D. Miodrag		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The aim of the course is to provide a comprehensive knowledge of the theory of model predictive control (MPC).			
Course outcomes	The student independently develops original robust and distributed predictive control methodologies for linear and nonlinear systems under system uncertainties. They critically analyze existing game theory solutions for constrained systems, moving horizon estimation, and advanced filters. They design innovative control laws, demonstrating scientific autonomy through the creation of new solutions applicable to complex processes.			
Course outline				
Theoretical teaching	Robust model predictive control. Types of uncertainty. Feedback versus open-loop control. Nominal robustness. Robust MPC design of nonlinear systems. State estimation. Moving horizon estimation (MHE). Extended Kalman filtering. Particle filtering. Combined MHE/particle filtering. Output MPC. Linear constrained systems. Offset-free MPC. Nonlinear constrained systems. Distributed MPC (DMPC). Introduction and consideration of the existing results. Unconstrained two-player game. Constrained two-player game. Constrained M-player game. Nonlinear DMPC. Explicit control laws for constrained linear systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	B. R. Rawlings , D.Q. Mayne, M. M. Diehl, Model Predictive Control: Theory, Computational and Design, Nob Hill Publishing, 2017.			
2	J. M. Maestre, R. R. Negenborn (Eds.), Distributed Model Predictive Control Made Easy, Springer, 2014.			
3	S. V. Raković, W. S. Levine, Handbook of Model Predictive Control, Springer International Publishing, 2018.			
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Teaching methods depends on number of students (lectures or individula work with supevisor). Students extend their lectures knowledge by reading scientific papers and other external literature. Students also get skills for writing scientific papers independently by consultations and research work. Students are obligatory to do a project for the final exam.			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Adaptive Control Systems		
Lecturer (for lectures)		Perić Lj. Staniša, Milovanović B. Miroslav		
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	12	Course status (obligatory/elective)	Elective	
Prerequisites	None			
Course objectives	The aim of the course is for students to master the theory and application of adaptive control, including modern methods based on artificial intelligence, in order to be prepared for research and development of intelligent control systems.			
Course outcomes	By the end of the course, students will have knowledge of adaptive control systems and will be capable of designing their own control structures.			
Course outline				
Theoretical teaching	Introduction to adaptive control. Mathematical foundations of adaptive systems. Classical real-time parameter estimation. Online parameter estimation: gradient methods and least squares methods in continuous and discrete time domains. Extremum-seeking methods. Basic principles of model reference control. Self-tuning regulators. Direct and indirect adaptive control: adaptive pole placement control, model reference control, adaptive model reference control, and adaptive backstepping control with tuning functions. Machine learning methods: neuro-adaptive control and reinforcement learning-based control. Adaptive control in distributed and networked systems. Practical aspects and implementation of adaptive control systems.			
Practical teaching (exercises, OFE, study and research work)				
Textbooks/references				
1	Shankar Sastry, Marc Bodson, "Adaptive Control: Stability, Convergence and Robustness ", Prentice Hall, 1994.			
2	Petros Ioannou, Jing Sun, "Robust adaptive control", Prentice Hall, 1996.			
3	George Rovithakis, Manolis Christodoulou, ""Adaptive Control with Recurrent High-order Neural Networks""", Springer, 2000.			
4	Ioan Landau, Rogelio Lozano, Mohammed M'Saad, Alireza Karimi, "Adaptive Control: Algorithms, Analysis and Applications", Springer, 2011.			
5	Petros Ioannou, "Adaptive Control Theory and Applications" IntechOpen, 2024.			
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
3	/	/	0	0
Teaching methods	Lectures/consultations (depending on the number of students); study-research work (literature review, problem analysis, finding solutions, writing and presenting an independent paper).			
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				
Projects		50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Scientific and Research Work 1		
Lecturer (for lectures)				
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		24	Course status (obligatory/elective)	Obligatory
Prerequisites				
Course objectives	Application of fundamental, theoretical-methodological, scientific-professional, and professionally-applicative knowledge and methods in solving specific problems. The student studies the problem, its structure and complexity, and based on conducted analyses, draws conclusions about possible ways to solve it. By studying the literature, the student becomes familiar with methods intended for solving similar tasks and with engineering practice in their resolution.			
Course outcomes	Enabling students to independently apply previously acquired knowledge from various fields they have studied, in order to understand the structure of a given problem and perform a systematic analysis to draw conclusions about possible directions for its resolution. Through the practical application of acquired knowledge, students develop the ability to perceive the role and place of engineers in the chosen field, the need for collaboration with other professions, and teamwork.			
Course outline				
Theoretical teaching	It is formed individually in accordance with the needs of a specific scientific or seminar paper, its complexity and structure. According to their affinities and interests, the student selects the scientific field of study or the subject teacher from the list of teachers in the study program who defines the specific task. The student studies professional literature and scientific works dealing with similar topics, performs analyses to find solutions to the specific task, or conducts certain experiments in the laboratory. The scientific work also includes active monitoring of primary knowledge, organization and execution of experiments, numerical simulations and statistical data processing, and the creation of a seminar or scientific paper within the narrower scientific-teaching field to which the topic of the independent research work belongs.			
Practical teaching (exercises, OFE, study and research work)	The experimental part of the work can be carried out in the laboratories of the study program.			
Textbooks/references				
1				
2				
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
			11	
Teaching methods	The subject teacher formulates the assignment and delivers it to the student. The student is required to complete the seminar paper within the given topic defined by the assignment, using the recommended literature. During the writing process, the subject teacher may provide additional instructions to the student, refer them to specific literature, and further guide them to ensure the seminar paper is of high quality. As part of the scientific-research work, the student consults with the subject teacher and, if necessary, with other teachers involved in the topic's field. Within the assigned topic, the student may also carry out certain measurements, examinations, and other research activities, as well as statistical data analysis, if specified in the assignment.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				

Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Scientific and Research Work 2		
Lecturer (for lectures)				
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS		24	Course status (obligatory/elective)	Obligatory
Prerequisites				
Course objectives		Application of fundamental, theoretical-methodological, scientific-professional, and professionally-applicative knowledge and methods in solving specific problems. The student studies the problem, its structure and complexity, and based on conducted analyses, draws conclusions about possible ways to solve it. By studying the literature, the student becomes familiar with methods intended for solving similar tasks and with engineering practice in their resolution.		
Course outcomes		Enabling students to independently apply previously acquired knowledge from various fields they have studied, in order to understand the structure of a given problem and perform a systematic analysis to draw conclusions about possible directions for its resolution. Through the practical application of acquired knowledge, students develop the ability to perceive the role and place of engineers in the chosen field, the need for collaboration with other professions, and teamwork.		
Course outline				
Theoretical teaching		It is formed individually in accordance with the needs of a specific scientific or seminar paper, its complexity and structure. According to their affinities and interests, the student selects the scientific field of study or the subject teacher from the list of teachers in the study program who defines the specific task. The student studies professional literature and scientific works dealing with similar topics, performs analyses to find solutions to the specific task, or conducts certain experiments in the laboratory. The scientific work also includes active monitoring of primary knowledge, organization and execution of experiments, numerical simulations and statistical data processing, and the creation of a seminar or scientific paper within the narrower scientific-teaching field to which the topic of the independent research work belongs.		
Practical teaching (exercises, OFE, study and research work)		The experimental part of the work can be carried out in the laboratories of the study program.		
Textbooks/references				
1				
2				
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
			11	
Teaching methods		The subject teacher formulates the assignment and delivers it to the student. The student is required to complete the seminar paper within the given topic defined by the assignment, using the recommended literature. During the writing process, the subject teacher may provide additional instructions to the student, refer them to specific literature, and further guide them to ensure the seminar paper is of high quality. As part of the scientific-research work, the student consults with the subject teacher and, if necessary, with other teachers involved in the topic's field. Within the assigned topic, the student may also carry out certain measurements, examinations, and other research activities, as well as statistical data analysis, if specified in the assignment.		
Grade (maximum number of points 100)				
Pre-exam duties		Points	Final exam	Points
Activity during lectures			Written exam	
Exercises			Oral exam	50
Colloquia				

Projects	50		

Specification for the book of courses

Study program		Electrical Engineering and Computer Science		
Type and level of studies		Doctoral Studies		
The name of the course		Scientific and Research Work 3		
Lecturer (for lectures)				
Lecturer/associate (for exercises)				
Lecturer/associate (for OFE)				
Number of ECTS	24	Course status (obligatory/elective)	Obligatory	
Prerequisites				
Course objectives	Application of fundamental, theoretical-methodological, scientific-professional, and professionally-applicative knowledge and methods in solving specific problems. The student studies the problem, its structure and complexity, and based on conducted analyses, draws conclusions about possible ways to solve it. By studying the literature, the student becomes familiar with methods intended for solving similar tasks and with engineering practice in their resolution.			
Course outcomes	Enabling students to independently apply previously acquired knowledge from various fields they have studied, in order to understand the structure of a given problem and perform a systematic analysis to draw conclusions about possible directions for its resolution. Through the practical application of acquired knowledge, students develop the ability to perceive the role and place of engineers in the chosen field, the need for collaboration with other professions, and teamwork.			
Course outline				
Theoretical teaching	It is formed individually in accordance with the needs of a specific scientific or seminar paper, its complexity and structure. According to their affinities and interests, the student selects the scientific field of study or the subject teacher from the list of teachers in the study program who defines the specific task. The student studies professional literature and scientific works dealing with similar topics, performs analyses to find solutions to the specific task, or conducts certain experiments in the laboratory. The scientific work also includes active monitoring of primary knowledge, organization and execution of experiments, numerical simulations and statistical data processing, and the creation of a seminar or scientific paper within the narrower scientific-teaching field to which the topic of the independent research work belongs.			
Practical teaching (exercises, OFE, study and research work)	The experimental part of the work can be carried out in the laboratories of the study program.			
Textbooks/references				
1				
2				
3				
4				
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	Exercises	OFE	Study and research work	Other classes
			11	
Teaching methods	The subject teacher formulates the assignment and delivers it to the student. The student is required to complete the seminar paper within the given topic defined by the assignment, using the recommended literature. During the writing process, the subject teacher may provide additional instructions to the student, refer them to specific literature, and further guide them to ensure the seminar paper is of high quality. As part of the scientific-research work, the student consults with the subject teacher and, if necessary, with other teachers involved in the topic's field. Within the assigned topic, the student may also carry out certain measurements, examinations, and other research activities, as well as statistical data analysis, if specified in the assignment.			
Grade (maximum number of points 100)				
Pre-exam duties	Points	Final exam		Points
Activity during lectures		Written exam		
Exercises		Oral exam		50
Colloquia				

Projects	50		