UNIVERSITETI I EVROPËS JUGLINDORE
УНИВЕРЗИТЕТ НА ЈУГОИСТОЧНА ЕВРОПА
SOUTH EAST EUROPEAN UNIVERSITY

Study program	Computer Sciences (2025/2026)
Faculty	Contemporary Sciences and Technologies
Study Cycle	Third Cycle (PhD)
ECTS	180
Code	PhD-CS-180
Title	Doctor of Computer Sciences
Accreditation archive number [180]	03-2387/1
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Decision for starting of the program	
Accreditation date	09.07.2025

Description of the program

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The proposed PhD program in Computer Science is designed to equip researchers with the technical expertise, methodological tools, and ethical grounding necessary to contribute to cutting-edge developments in the field. The program's comprehensive curriculum addresses emerging technologies, advanced computational techniques, and critical areas of research, creating well-rounded computer scientists ready to tackle complex challenges. Here's a justification for each aspect of the curriculum:

Research Methodology and Scientific Writing
Grounding students in research methodologies is essential for producing original, high-quality research. Courses on research methods, proposal writing, and scientific reporting ensure that students can formulate research problems, conduct systematic inquiries, and communicate their findings effectively. Research ethics is vital to fostering integrity in publications and maintaining public trust in scientific advancements.

Core and Emerging Areas of Computer Science
These courses focus on both foundational and cutting-edge areas of Computer Science. Machine learning, cloud computing, and AI are central to modern computational advancements. The inclusion of Large Language Models (LLM), IoT, and NLP reflects current trends and real-world applications, ensuring that students are well-versed in technologies shaping various industries such as automation, healthcare, and communication.

Data and Security
The ability to process, analyze, and secure large datasets is a core competency for modern computer scientists. These courses provide students with the statistical tools and security frameworks needed to manage and protect vast amounts of data. With increasing concerns around cybersecurity and data privacy, these skills are in high demand across both academia and industry.

Networking and Social Sciences Integration

Network sciences and social network analysis are critical in understanding the behavior of complex systems, whether in computer networks or human interaction on digital platforms. These courses enable students to explore interdisciplinary research, particularly in the realms of social computing, network modeling, and the role of networks in information dissemination.

Advanced Computing and Specialized Topics
Advanced courses like augmented/virtual reality, federated learning, and specialized data topics prepare students to work on niche research problems that are at the forefront of innovation. Operations research introduces analytical decision-making techniques that are critical for optimizing systems and processes, especially in industrial and business environments.

Electives and Customization
Offering electives ensures that students can tailor their learning experience according to their research interests. This flexibility allows for specialization in niche areas, fostering a personalized approach to doctoral studies and encouraging interdisciplinary research collaborations.

The structure of this PhD program reflects a balance between theoretical knowledge, practical skills, and emerging technologies. The inclusion of foundational courses alongside advanced topics ensures that graduates are prepared not only to contribute to academia but also to lead innovation in industry. The emphasis on research, ethics, and publication prepares students to produce credible and influential scientific work.

This program is aligned with the growing demand for specialists in areas like AI, machine learning, big data analytics, and cybersecurity. As technology continues to evolve, professionals equipped with deep technical knowledge and a strong ethical framework will be in high demand, positioning graduates from this program as leaders in the computer science field.

Career

The program provides continuing education of personnel, who have completed undergraduate and postgraduate studies. The program will enable the highest level of scientific-research preparation in the professional field and own research activities, as well as in professional and academic career. In this process of study, students will be equipped with competencies and academic, intellectual and technical communications skills through various forms and will be prepared for scientific research work. Rapid changes in society impose and require new approaches for preparing new generations of scientific knowledge to the needs of the knowledge-based society and are dedicated to the global labor market in the field of Computer Sciences.

Learning outcomes

Knowledge and understanding

Possession of knowledge and understanding of Computer Sciences areas and information architectures, network societies and internet cultures, Internet and web technologies proportionally expanded in comparison with second cycle studies.
Ability to develop and implement original and creative ideas in environments where overlapping or related fields of Information Technology occur.
Ability to apply interdisciplinary knowledge and demonstration of specialist competencies in Information Technology.

Applying knowledge and understanding

Ability to critically, independently and creatively solve problems in new, previously not encountered or environments for which has no prior experience in a multidisciplinary context of real organizational environment.
Planning, managing and evaluation of independent research in the field of Computer Sciences implementing appropriate Calculator tools, environments and technologies.
Creativity and originality in the interpretation of the knowledge of e-technological processes and appropriate use of computer-based tools and environments based on defined techniques for research and investigation.

Making judgement

Ability for creative integration and synthesis of knowledge from many areas related to media processes and use of computer tools and techniques.
Ability to deal with complex situations related to process-specific technologies, the identification of appropriate specialized domain instances in the internet and informatics and making sound judgments in situations lacking complete information or

data based on personal, social and ethical principles and responsibilities related to the application of knowledge and understanding.

Communication skills

Ability to clearly and unambiguously communicate conclusions, results, studies and knowledge of Computer Sciences specialists' areas with the ability to adapt to the style and form of expression for non-specialists.
Competence for critical, independent and creative argumentative research, evaluation methodologies and proposing and defending new hypotheses.
Ability to initiate, conduct, and taking responsibility for individuals and groups in cases where communication, organizational and informatics competencies are of essential importance.

Learning skills

Ability to identify personal needs and directions for individual and autonomous additional education and its performance independently and autonomously in the Computer Science areas.
Ability to assume responsibility for continuous individual learning in specialized and new e- technologies.

List of courses

Semester 1

- [C2515] [10.0 ECTS] **Research Methods in Computer Sciences**
- [C2516] [10.0 ECTS] **Advanced Machine Learning**
- [C2517] [10.0 ECTS] **Advanced Cloud Computing**

Semester 2

- [C2518] [10.0 ECTS] **Advanced Software Architectures and Testing**
- [10.0 ECTS] **Elective Course**
- [10.0 ECTS] **Elective Course**

Semester 3

- [C2604] [10.0 ECTS] **Doctoral Project Proposal**
- [C2605] [20.0 ECTS] **Doctoral Seminar with a Presentation of the Report I**

Semester 4

- [C2521] [20.0 ECTS] **Research Output I**
- [C2522] [10.0 ECTS] **Student Mobility**

Semester 5

- [C2523] [20.0 ECTS] **Doctoral Seminar with a Presentation of the Report II**
- [C2524] [10.0 ECTS] **Research Output II**

Semester 6

- [C2525] [30.0 ECTS] **Doctoral Dissertation**

Description of courses

Core courses

- **Research Methods in Computer Sciences**
  Course objectives: • Equip students with advanced research methodologies in computer science. • Develop skills to design, conduct, and evaluate independent research. • Enhance critical evaluation of scientific literature and

research ethics. • Prepare students for dissertation research with strong methodological foundations. Learning outcomes: By the end of the course, students will be able to: • Select and apply appropriate research methods for computer science research. • Formulate research questions, conduct literature reviews, and design studies. • Analyze and interpret research data using suitable tools. • Communicate research findings effectively in academic formats. • Develop ethical research practices and prepare a PhD-level research proposal.

- **Advanced Machine Learning**
  The course aims to provide students with advanced competencies in machine learning techniques and methodologies, equipping them with the ability to apply linear algebra, probability, and statistics in real-world data problems. Students will develop programming proficiency in Python or a similar language and gain experience in data preprocessing and analysis. By the end of the course, they will be able to design, implement, and evaluate complex machine learning models, preparing them for academic research or industry roles that require advanced data handling and machine learning expertise.

- **Advanced Cloud Computing**
  This course introduces students to the state-of-the-art in Cloud Computing technologies and applications. The course starts with an overview and continue with in-depth understanding of the Cloud Computing. The course focus is on cloud infrastructures, cloud computing services, types, models, security issues, Quality of Service (QoS), Service-Level Agreements (SLA), Virtual Machines, performance monitoring, pricing (billing), risk management, tools for building different types of clouds, legal issues in cloud computing, scientific computing, business computing on clouds, and novel applications of cloud computing. Some of those topics will be introduced. The course aims also to identify potential research directions in field of Cloud Computing. At the end of this course, students should be able to: • Understand cloud computing, overview of cloud computing; • Understand the build of cloud, structures, cloud layers and architectures; • Understand the use and importance, limitations, advantages and disadvantages of the cloud technology; • Understand the cloud development and perspective; • Understand cloud programming platforms and technologies; • Understand security issues on the cloud computing/processing and technologies and to be capable in coping with security issues; • Identify research directions on field of cloud processing;

- **Advanced Software Architectures and Testing**
  The objective of the "Advanced Software Architectures and Testing" course is to foster critical thinking and research skills in students, enabling them to investigate and contribute to the development of innovative architectural frameworks and testing methodologies. Students will engage in cutting-edge research, analyse emerging trends, and explore the impact of software architecture on system performance, scalability, and maintainability, ultimately preparing them to advance the field through scholarly inquiry and practical application.

- **Doctoral Project Proposal**
  After the second semester, students begin their activities for the development of the plan on his/her doctoral dissertation. Activities include the definition of literature, defining hypothetical framework, the definition of the work methodology and determination of the individual plan as well as the first public presentation. If necessary, can be held elective courses for this purpose.

- **Doctoral Seminar with a Presentation of the Report I**
  Candidates will submit a list of all seminars attended, which are relevant to their field and/or their research interest at anywhere in the world, on the attached prescribed form to their supervisors for acknowledgement. These seminars should be research in nature. A report should be written by the students in his/her own words for each seminar attended. The report summarizes key points and provides student’s critical assessment. The student is typically required to initiate a discussion with fellow researchers on the topic to help him/her write the report.

- **Research Output I**
  At the end of the 4th semester, after the research activities under the individual plan, overall results of this phase of the paper and the research will be presented publicly by the candidate.

- **Student Mobility**
  During the fourth semester the student is obliged to visit and contribute to a relevant institution abroad for a period of at least one week. The aim of PhD students’ mobility is to request candidates to present, exchange and discuss their research work with their colleagues from other countries for improving the quality of their dissertation. For the realization of mobility, the student brings evidence to the mentor.

- **Doctoral Seminar with a Presentation of the Report II**
  Candidates will submit a list of all seminars attended, which are relevant to their field and/or their research interest at anywhere in the world, on the attached prescribed form to their supervisors for acknowledgement. These seminars should be research in nature. A report should be written by the students in his/her own words for each seminar attended. The report summarizes key points and provides student's critical assessment. The student is typically required to initiate a discussion with fellow researchers on the topic to help him/her write the report.

- **Research Output II**
  At the end of the 5th semester, after the research activities under the individual plan, overall results of this phase of the paper and the research will be presented publicly by the candidate.

- **Doctoral Dissertation**
  Continuation of the doctoral dissertation work. The thesis (dissertation) is submitted, accepted by the Faculty's Teaching and Scientific Council, submitted to the committee members, and the public defense procedure begins.

Elective courses

- **Research Paper and Scientific Report Writing**
  The course aims is: - to provide an understanding and knowledge of the key principles of scientific writing and reporting. Students build up basic skills in producing student research papers, beginning from choosing a research topic or problem, then defining a research aim and specific research tasks, selecting research methods, designing the structure of the research through to representing the research results. Students learn the basics of scientific and methodological matters and acquire practical skills needed for further research. In the course attention is paid to practical use of databases where scientific papers are available, on preparing effective tables and figures. Students learn how to use appropriate units of measurements, how to analyse scientific literature, put references in text and prepare List of References. The course explains preconditions for preparation of successful posters and oral reports. - to develop practical competences and critical understanding of knowledge in the development and reporting of scientific research papers.

- **Research Proposal and Project Management**
  The objective of the course is that students should be able to: 1. demonstrate an ability to plan a research project, such as is required in a research proposal prior to the launch of their work 2. demonstrate an ability to comply with ethical, safety, and documentation processes appropriate to their project 3. demonstrate expert knowledge in the subject of their research project, such as through a integrated literature survey 4. demonstrate expert knowledge in the research methods appropriate to generating reliable data for their research questions 5. demonstrate the ability to project management and to make constructive use of expertise associated with their project, while working as an independent learner 6. demonstrate an ability to relate their original data to existing literature, or to create a novel synthesis of existing materials 7. demonstrate an ability to assemble their findings into a substantial piece of writing that presents a clear thesis and a cohesive, evidence-based argument 8. demonstrate an ability to balance description, analysis, and synthesis within their project report.

- **Research and Publication Ethics in Computer Science**
  Aims of the Course Program: Ethical Awareness in Research: • Develop the ability to recognize ethical challenges specific to computer science research. • Promote the importance of responsible research practices and professional integrity. Competency in Publication Ethics: • Equip students with knowledge about ethical practices in writing, peer-review, and publishing. • Foster an understanding of plagiarism, data fabrication, and conflicts of interest in research publications. Skills for Open Science and Data Ethics: • Build proficiency in handling research data with integrity, transparency, and reproducibility. • Encourage awareness about data privacy, informed consent, and the ethical use of algorithms. Regulatory and Professional Compliance: • Familiarize students with local and international research policies, publication regulations, and ethical codes (e.g., IEEE/ACM guidelines). Critical Thinking and Ethical Decision-Making: • Develop competencies to analyze case studies and address ethical dilemmas arising in advanced computer science research areas such as AI, cybersecurity, and big data.

- **Selected Topics in Data Engineering**
  This course will discuss and study research topics and current problems of interest in the field of data engineering. The course will go beyond the principles and concepts of data engineering and big data architecture and will focus on

how data engineers work with big data. Students will be able to develop a better understanding of how to build, schedule and monitor data pipelines. This understanding will advance their knowledge on data storage architectures, extend the knowledge on non-relational databases, and advanced practical knowledge of data warehouses in AI and machine learning methodologies. The aims of the course are to: ? Demonstrate an advanced understanding of data engineering and data architectures, programming languages and data engineering skills to deliver robust and scalable solutions ? Develop a critical awareness of current issues and developments in data engineering. Demonstrate the ability to apply data engineering tools and techniques on-premise and using cloud platform technology to develop data solutions in business.

- **System and Data Security**
  Objectives Introduction to the problem of security of information systems and data. Obtain detailed knowledge about the main weaknesses intrinsic to the operating systems and computers. Presentation of methods for building systems capable of withstanding attacks, operating errors and chance occurrences caused by intelligent opponents. Study of tools, processes and methods needed to plan, implement and test secure systems and adapt existing systems to real contextual environments constantly evolving. Learning outcomes and competences At the end of the course students should be able to: Identify, assess and diagnose possible failures, risks and vulnerabilities in information systems. Understand authentication systems and access control and how to use them to implement security policies. Understand the goals and use of automated intrusion detection systems. Understand the security issues in software development and techniques to avoid them.

- **Applied Statistics and Data Processing**
  This course aims to equip students with advanced skills in applied statistics and data processing, emphasizing research elements for real-world applications. Students will master advanced statistical techniques for data analysis and will use modern tools for processing large datasets. The course also prepares students to conduct statistical research and develop models for prediction and inference. Learning Outcomes: • Students will understand and apply advanced descriptive and inferential statistical methods in data analysis. • Students will utilize probability theory to model and interpret uncertainties in data. • Students will apply regression techniques and statistical models for accurate prediction. • Students will gain skills in handling and analyzing large and complex datasets. • Students will develop proficiency in using Python or R for data processing and analysis. • Students will be able to construct and implement statistical models for research projects and industry applications.

- **Large Language Models (LLM)**
  This course aims to cover cutting-edge research topics centering around pre-trained language models. We will include topics related to technical foundations (BERT and GPT) also focus on RAG and other emerging capabilities, fine-tuning, but also include topics on data governance and ethics. Majority of issues discussed throughout the semester will be based on reviewing research papers on the topic. Students will be expected to read, analyze and present research papers on weekly basis. Learning goals: • To prepare students for conducing state-of-the-art research in LLMs and GenAI, analyze research and introduce gaps. • Practice your research skills such as conducting literature review, write own papers in the field of LLM as well as providing constructive feedback. • Gain hands-on experience through the final project, critically evaluating different language modeling approaches and developing independent research projects and writing the final paper.

- **Internet of Things (IoT)**
  Aims of the Course Program: ● Develop advanced knowledge of IoT technologies and communication protocols. ● Equip students with skills to design and deploy IoT systems in real-world applications. ● Enhance problem-solving abilities in integrating IoT across different sectors. ● Build practical competencies in cloud computing and embedded systems for IoT. Learning Outcomes: ● Understand IoT architecture and components. ● Design and implement IoT solutions. ● Analyze and optimize IoT system performance. ● Develop and present an IoT project.

- **Natural Language Processing (NLP)**
  The aim of this course is to provide students with a comprehensive understanding of natural language processing (NLP) techniques and practical frameworks. Students will develop skills in text preprocessing, word embeddings, and vectorization, while building machine learning and deep learning models for tasks like text classification, named entity recognition, and sentiment analysis. They will gain hands-on experience with advanced models, including transformers and large language models (LLMs), for tasks such as machine translation and question answering, as well as integrating speech recognition with NLP for end-to-end applications. Students will learn to evaluate models using key metrics, conduct error analysis, and explore emerging trends, preparing them for both industry and research roles in NLP. By the end of the course, students will be able to apply preprocessing techniques, build and fine-tune NLP models, integrate speech recognition with NLP, and address ethical challenges. They will gain the ability to assess model performance with metrics like F1 score, BLEU, and ROUGE, and interpret results effectively.

Additionally, they will explore future trends, including multi-modal NLP and domain-specific applications, equipping them to tackle real-world challenges in various fields such as healthcare, law, and social media analytics.

- **AI and Applications**
  The course aims to deepen students' understanding of both foundational and advanced AI concepts while fostering critical research skills for original contributions to the field. It encourages an interdisciplinary approach, exploring how AI intersects with various domains, and emphasizes the importance of ethical considerations in technology. Students will develop essential competencies, including analytical and technical skills, expertise in research methodology, effective communication, and ethical judgment. By the end of the program, they will have mastered key AI theories and methodologies, produced original research, and applied AI techniques to real-world challenges. Additionally, they will be equipped to critically evaluate existing literature and articulate the ethical implications of their work, advocating for responsible AI practices in their future careers.

- **Federated Learning**
  The course on "Federated Learning" aims to provide students with a comprehensive understanding of the fundamental concepts and principles that underpin this innovative approach to decentralized machine learning. Students will explore key algorithms, such as Federated Averaging, tailored for environments where data remains on local devices, while also delving into crucial topics like data privacy and security through methods like differential privacy and secure multi-party computation. Hands-on implementation using popular frameworks like TensorFlow Federated will allow students to apply their knowledge practically, assessing model performance through various metrics related to efficiency, accuracy, and privacy. Additionally, the course will cover real-world applications across sectors such as healthcare, finance, and IoT, highlighting both the benefits and challenges associated with federated learning. Students will also engage with ongoing research trends and ethical considerations, particularly regarding data ownership and algorithmic fairness, fostering critical thinking and encouraging contributions to the evolving field. Ultimately, by the end of the course, participants will be well-equipped to design, implement, and critically evaluate federated learning systems.

- **Network Sciences**
  Aims of the Course Program: ● Understand network structures and dynamics. ● Analyze and interpret large-scale network data. ● Model and simulate complex networks. ● Present research findings effectively. Learning Outcomes: ● Master fundamental network science concepts. ● Apply mathematical tools for network analysis. ● Use software for network visualization. ● Design and execute a research project in network science.

- **Selected Topics in Social Network Sciences**
  This course introduces mathematical methods and computational tools for Social Network Analysis (SNA). Originally pioneered by sociologists, SNA has expanded into an interdisciplinary field, with contributions from mathematicians, computer scientists, physicists, and economists, bringing new techniques for analyzing networks. The course starts with basic statistical descriptions of networks, exploring structures, node roles, connectivity patterns, and methods for community detection. Later, it delves into processes on networks, practical approaches to network visualization, and concludes with real-world applications, including social media mining and the analysis of actual real platforms. Upon completing this course students will: Understand the fundamental notation and terminology of network science. Be able to visualize, summarize, and compare networks effectively. Grasp the core principles of network analysis algorithms. Acquire practical skills in performing network analysis using the Python programming language. Be prepared to analyze real-world networks independently.

- **Augmented and Virtual Reality**
  The course "Augmented and Virtual Reality" aims to equip students with a comprehensive understanding of the technologies and principles underlying immersive environments, fostering competencies in theoretical knowledge, technical proficiency, and innovative design. Students will develop advanced research skills, enabling them to critically analyze existing literature, conduct independent research, and create immersive applications that enhance user experiences.

- **Big Data Analytics**
  The objective of this course is to equip students with the knowledge and practical skills necessary to handle, analyze, and derive insights from large-scale datasets using modern Big Data tools and techniques. The course focuses on both the technical aspects, such as working with distributed computing frameworks (Hadoop, Spark, Flink) and cloud platforms (AWS, Google Cloud, Azure), and the theoretical aspects, including statistical analysis, machine learning models, and visualization. Students will gain a comprehensive understanding of how to process, analyze, and interpret Big Data to support decision-making, while also considering ethical and privacy concerns. Upon successful completion of this course, students will: • Perform data gathering and management from a variety of large-scale data

sources. • Critically analyze existing Big Data implementations, assessing their practicality and usefulness. • Understand and apply statistical measures to analyze large datasets and present summary statistics. • Demonstrate advanced knowledge of statistical and machine learning analytics applied to Big Data. • Communicate data-driven insights effectively through visualizations and clear summaries. Understand the ethical, legal, and privacy concerns related to Big Data analytics and apply best practices to ensure compliance.

- **Statistical Data Analysis**
  The course aims to enhance students' understanding of advanced statistical theories and their application in the field of data analysis. The course will start with basic and necessary statistical theories applied in data analysis and continues with advanced multivariate techniques for analyzing complex datasets. Students will learn to construct and interpret statistical models, emphasizing the importance of understanding assumptions and implications. Additionally, the course will introduce Bayesian methods for inference and decision-making and creating effective data visualizations to clearly communicate statistical results. Familiarity with programming tools and computational techniques for advanced statistical analysis will be a key component. The course will illustrate the application of statistical methods across various fields of data analysis, promoting integrative problem-solving, and having into consideration a strong commitment to ethical practices in statistical data analysis. Overall, these aims prepare PhD students for impactful research careers by equipping them with essential theoretical knowledge, practical skills, and ethical considerations in statistical data analysis.

- **Operations Research**
  The learning objectives of the course are: - Gain a solid grasp of the basic concepts and terminology in operations research, including optimization, modeling, and simulation. - Develop the ability to formulate real-world problems into mathematical models, identifying relevant variables, constraints, and objectives. - Learn various optimization methods, including linear programming, integer programming, and nonlinear programming, and understand when to apply each technique. - Understand the principles of simulation, including discrete-event simulation, and learn how to use simulation tools to analyze complex systems. - Learn how to assess different decision-making scenarios using decision trees, sensitivity analysis, and risk assessment techniques. - Explore the application of OR techniques in supply chain management, production planning, and inventory control. - Enhance analytical thinking and problem-solving skills to approach complex operational issues systematically. - Develop the ability to communicate results effectively, both in written reports and oral presentations, to diverse audiences.