# Specification of courses in the study program of doctoral studies

| No. | Course title |
|---|---|
| 1. | Methodology of scientific research in IT |
| 2. | Methods and techniques of artificial intelligence |
| 3. | IT and knowledge management |
| 4. | Mathematical Modelling |
| 5. | Software quality |
| 6. | Web mining |
| 7. | Decision Support Systems |
| 8. | Electronic Business |
| 9. | Computer simulation and animation |
| 10. | Data Science |
| 11. | Applied computer vision |
| 12. | Intelligent educational systems |
| 13. | Protection of Computer Systems |
| 14. | Contemporary Modern network technologies |
| 15. | Information Systems Development |
| 16. | Scientific-research project 1 |
| 17. | Scientific-research project 2 |
| 18. | Doctoral thesis (theoretical foundations) |
| 19. | Doctoral thesis - Scientific-research project |
| 20. | Doctoral Thesis-production and defense |

**Course title: Methodology of scientific research in IT**

**Teacher(s): Danijela M. Milošević, Veljko V. Aleksić, Marjan D. Milošević**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

Gaining understanding of general concepts of scientific research methodology and acquiring knowledge of basic scientific research techniques especially adapted to the scientific fields of the state-of-the-art technologies which are rapidly developing.

**Learning outcomes**

The student will be introduced to scientific theories and research methods that are relevant to the field of research in information technology. The student will be able to identify key research issues, formulate a research question, plan and implement a research project, demonstrate understanding of the limits and possibilities of research in information technology as well as to gain experience in writing scientific work in accordance with academic integrity, as well as ethics code and principles.

**Contents**

*Theoretical classes*

Scientific theories and sources of information, repositories. Ethical frameworks of scientific research. Methods and stages in the process of scientific research. Methods of collecting scientific information. Comparison and classification of scientific resources. Specifics of the approach in fast growing scientific field of information technologies. Analysis and synthesis of scientific opinion. Induction and deduction as methods of cognition of scientific thinking. Defining problems and subjects of research, planning research. Data collection and processing. Hypothesis testing and simulation. Scientific reasoning. Criteria for evaluating research results. Systematization and presentation of research results. Patents. Intellectual property.

*Practical teaching*

Search and collection of various sources of scientific material in the field of IT. Selection, processing and presentation of results. Development of research plan and concept of scientific work.

**Recommended literature**


[1] Bjekić, D. (2010), Methods of scientific research and communication, Čačak, Technical faculty.

[2] Vuković, M., Štrbac, N. (2019), Methodology of scientific research, Bor, ISBN 978-86-6305-086-0, Technical faculty Bor, University of Belgrade.

[3] Ryhan Ebad (2013). Research Methodology in Computer Science, Centrum Press, India.

[4] *Geetanjali V. Kale and J. Jayanth*, (2019), Research Methodology, A Practical and Scientific Approach, ISBN 9780815385615, Chapman and Hall/CRC

[5] Laura Palazzani (2019) Innovation in Scientific Research and Emerging Technologies: A Challenge to Ethics and Law, ISBN 978-3030167325, Springer


| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Verbal and discussions, practical workshops, online discussions, collaborative learning. The subject is supported with online course.

**Evaluation (maximum number of points 100)**

Activities during teaching process: 10 points

Project work: 40

Final part of the exam: 50 points


<<<List of subjects

**Course title: Methods and techniques of artificial intelligence**

**Teacher(s): Vanja V. Luković and Danijela M. Milošević**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: No**

**Course objectives**

Students will acquire new theoretical and practical knowledge in the field of artificial intelligence and will be able to apply them in various fields. Acquiring knowledge for further independent research work in one of the fields of artificial intelligence.

**Learning outcomes**

Students will be able to independently apply some of the proposed methods and will be trained in a critical approach to their evaluation. Students will be trained for further research in the domains of current theoretical topics.

**Contents**

*Theoretical classes*

Artificial intelligence: an overview of the whole area. Concept and definitions of artificial intelligence. Theoretical foundations: presentation of knowledge and conclusions. Intelligent search. Machine learning. Probabilistic models and intelligent reasoning. Application of methods and techniques of artificial intelligence: intelligent agents. Neural networks. Text analysis and comprehension. Semantic Web. Artificial intelligence technologies. Neural networks.

*Practical teaching*

Application of software tools and practical implementation of projects in selected areas of artificial intelligence.

**Recommended literature**

[1] Stuart Russell, Peter Norvig: „*Artificial intelligence: a modern approach, third edition*“, Copyright 2010, 2003, 1995 by Pearson Education, Inc., Upper Saddle River, New Jersey 07458., ISBN-13: 978-0-13 -604259-4, ISBN-10: 0-13-604259-7.

[2] Proceedings of the International Conference *AAAI Conference on Artificial Intelligence* (http://www.aaai.org/Conferences/AAAI/aaai.php)

[3] Sebastian Raschka: „*Python Machine Learning*“, Packt Publishing - ebooks Account, 2015, ISBN: 978-1783555130.

Scientific papers from the journal from the SCI list in accordance with the affinities of the student

| | | |
|---|---|---|
| Number of active classes: 10 | Theory: 5 | Practice: 2 |

**Teaching methods**

Presentations and practical study examples related to certain techniques and software tools. Work with software tools in the laboratory and independent development of projects in the field of artificial intelligence.

**Evaluation (maximum number of points 100)**

Seminar paper - 20

Experimental research work with presentation - 30

Oral exam - 50

Ways of testing the knowledge may vary: (written tests, oral exam, project presentation, seminars etc.)

*maximum length 1 A4 page

<<< List of subjects

**Course title: IT and knowledge management**

**Teacher(s): Marija D. Blagojević, Miloš Ž. Papić**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

Objectives are defined by innovations in the spiral of product life cycle (for example, IT, systems and knowledge management) to: 1) familiarize candidates with the needs of planning knowledge upgrades; 2) research on the innovation of knowledge sources, on projects that include practical problems, including the finalization of part of the knowledge from the relevant sub / area; 3) checking the independence of the candidate in the chosen field of knowledge; 4) improving the solution of the problem.

**Learning outcomes**

The candidate is able to research and manage knowledge (for example and by life stages of IT products / systems / processes) so that independently: 1) plans continuous improvement of knowledge, 2) implements research project, organizes processes, compares index parameters of innovation, applies acquired knowledge in solving real problems, 3) self-assesses the level of (and its) scientific results (by clusters of knowledge innovation), 4) contributes to the improvement of the expected level.

**Contents**

**Theoretical classes**

The process of research work (in addition to getting acquainted with the methodology, in the selected sub / area and in comparison with IT and other areas of greatest intensity of innovation) includes:
1- selection of thematic sub-areas (according to the standardized SRPS and international ISO / IEC classification of all areas of work and creativity - ICS = 01 to 99, for IT - ICS = 35, [4], [5]),
2- defining the subject of work, methodology of work, goals of work (in accordance with the goals of the subject), realization of research (data collection, processing and analysis of results),
3- defining clusters for self-assessment of needs, possibilities and outcomes in the realization of knowledge innovation (daily, weekly, monthly and annually),
4- analyzing the contribution to the improvement of problem solving (on examples of modeling excellence): systems, products, processes, activities and tasks.

**Practical classes**

It is performed through consultations and research work in the chosen domain, with sources of knowledge (on examples of IT products - software and design services), including standardized phases:
1- project planning according to the lines of innovation trends of knowledge sources in selected sub-areas,
2- preparation of the paper with determination and comparison of quantitative indices (quantities and values of knowledge sources),
3- checking the results of work, metrics, evaluation and quantitative evaluation of results,
4- proposals for improving the "critical" elements of the model of excellence.

**Recommended literature**

[1] Micić, Ž., IT in integrated systems, Decision of the Scientific-Teaching Council of the Technical Faculty, No. VIII-1232/14 of 13 June 2007, COBISS.SR-ID 146094860, ISBN 978-86-901809-6-7 , Technical Faculty Čačak, 2008
[2] Micic Zivadin, Micic Milos, Blagojevic Marija, "ICT innovations at the platform of standardization for knowledge quality in PDCA", Computer Standards and Interfaces, Volume 36, Issue 1, (2013) pp. 231-243. ISSN 0920-5489
[3] Micić Živadin, Blagojević Marija, Micić Miloš, "Innovation and knowledge trends through standardization of IT applications", Computer Standards and Interfaces, Volume 36, Issue 2, Issue 2, (2014) pp. 423-434. ISSN 0920-5489
[4] *** ISO, ISO Store, Standards catalog, 35: IT, http://www.iso.org/iso/home/store/catalogue_ics.htm,
[5] *** ISS - Institute for Standardization of Serbia: http://www.iss.rs/,
http://www.iss.rs/standard/advance_search.php

| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Lectures, consultations and study research work with the realization of theoretical and practical interactive hybrid teaching, with cooperative study research and problem solving in the chosen domain of knowledge.

**Evaluation (maximum number of points 100)**

Prerequisites: 50 points
Final part of the exam: 50 points

Ways of testing the knowledge may vary: (written tests, oral exam, project presentation, seminars etc.)

*maximum length 1 A4 page

<<< List of subjects

**Course title: Mathematical Modelling**

**Teacher(s): Nada Ž. Damljanović**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: No**

**Course objectives**

Introduction to ideas and concepts of mathematical modelling of real phenomena and processes, types of mathematical models, construction and implementation of mathematical models.

**Learning outcomes**

Depending on the process to be modelled, students would be able to choose the appropriate mathematical model: to properly formulate variables, to analyse the mutual influence of parameters in the model, to optimise the number of operations in the model, to perform simulation experiments and to analyse and forecast real processes.

**Contents**

*Theoretical classes*

History of modelling and types of models. Methodology of mathematical modelling. Discrete event systems. Dynamic systems. Fuzzy systems. Modeling of inputs. Model verification and validation. Output analysis. The concept of determinisation and minimization of systems. Linear programming models. Dynamic programming models. Heuristic programming. Computational complexity of problems and algorithms. Special and General Heuristics. Models of multicriteria analysis. Stochastic type models. Fuzzy models. Modeling of uncertainty, fuzzy logic and approximate reasoning. Applications for modeling of organizational, business, production, service and computer systems.

*Practical classes*

Solving concrete problems based on the exposed theoretical concepts and principles. The course includes individual research study, active monitoring of scientific resources and their systematization, analysis, solving specific problems and preparation of scientific papers for publication.

**Recommended literature**

[1] Jovanović, T., Quantitative methods, Faculty of Mechanical Engineering, Belgrade, 1996.
[2] Lipovac, D., Radojičić, M., Letić, D., Optimisation models, ICIM, Kruševac, 1999.
[3] Om Parkash (Ed.), Mathematical Modeling, Optimization and Information Technology, Lambert Academic Publishers, Germany, 2015.
[4] Radojičić, M., Žižović, M., Application of multicriteria analysis methods in business decision making, Technical Faculty in Čačak, 1998.

| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

The lectures are performed using classical methods of teaching in combination with video projector and active interaction with students. Knowledge of students is tested by homework, midterm exam, and final exam (written and oral). At the final, a comprehensive understanding of the exposed material is checked.

**Evaluation (maximum number of points 100)**

Homework: 10 points;
Seminar paper: 20 points;
Final exam: 70 points.

<<<List of subjects

**Course title: Software quality**

**Teacher(s): Olga M. Ristic, Marjan D. Milosevic**

**Course status: elective**

**Number of ECTS credits:10**

**Condition: None**

**Course objectives**
Preparation for scientific research in the field of software quality assurance.

**Learning outcomes**
Ability of students to understand the quality of software, as well as gaining practical experience in the application of software quality management processes.

**Contents**
*Theoretical lectures*

The concept of software quality and software quality assurance. Software quality assurance requirements. Software quality models. Software quality testing. Quality measurement. Quality metrics. The price of software quality assurance. Software defects and their correction. Verification and validation. Processes, procedures and policies in software quality assurance. Software quality assurance planning. Reliability of software and software quality assurance techniques. Software quality assurance team organization. Case study.

*Practical lectures*
Part of the teaching is realized through independent research work in the field of software quality assurance. Study research work includes active survey of scientific literature, organization and performance of experiments, data processing, writing a scientific paper in the scientific field to which the topic of the doctoral dissertation belongs.

**Recommended literature**
[1]M. A. Levin, T. T. Kalal, J. Rodin, *Improving Product Reliability and Software Quality*, John Wiley & Sons, Ltd, 2019.
[2]Daniel Galin, *Software Quality Concepts and Practice*, Willey, 2018.
[3]Lewis, William E. *Software testing and continuous quality improvement*, Taylor & Francis Group, 2009.
[4]Scientific journals in the field of software quality:*Quality Engineering*, *Software Quality Journal*, *Software Testing Verification and Reliability*.

| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**
Lectures, consultations. Study research.

**Evaluation (maximum number of points 100)**
Homework- 20
Seminars- 30
Oral exam- 50

<<<List of subjects

**Course title: Web mining**

**Teacher(s): Marija D. Blagojević**

**Course status: elective**

**Number of ECTS credits:** 10

**Condition: None**

**Course objectives**

The aim of the course is to train students for independent scientific research work in the field of Web mining. Introducing students to the basic methods and techniques of Web mining, with special emphasis on applications in certain technical disciplines. Web Content Mining. Mining Web structures. Web usage mining. In addition to the mathematical basis of the method, special attention is paid to the application to solve specific problems.

**Learning outcomes**

Master the algorithms and techniques of Web mining. Use of ready-made software packages and applications in selected technical disciplines. Using Web Mining Techniques to Analyze Web Content, Structure, and Usage. Knowledge of the mathematical basis of Web mining methods. Recognizing the benefits of applying Web mining methods. Students are able to independently analyze and solve problems in the field of Web mining, as well as to conduct research in the field of application of advanced concepts in these areas.

**Contents**

Theoretical classes

Introduction to Web mining. Techniques for analyzing the content of Web documents. Classification and clustering of documents. Web structure analysis, ranking documents by importance. Website Rating Improvement Techniques. Web access analysis. Discovering the patterns of behavior of website users. Web visualization. Social network statistics.

Practical teaching

Web mining software. Application of Web mining in selected technical disciplines. Application of Web mining techniques for analysis of Web content, structure and usage. Analysis of mathematical bases of Web mining method techniques.

**Recommended literature**

[1] Bing Liu: Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data, Springer, Heidelberg; New York, 2011

[2] Jiawei Han and Micheline Kamber, Data mining, Elsevier, 2006/

[3] Matthew A. Russell, Mining the Social Web, O'Reilly Media, 2013.

| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Lectures, consultations, and study research work.

**Evaluation (maximum number of points 100)**

Prerequisites: 50 points

Final part of the exam: 50 points

Ways of testing the knowledge may vary: (written tests, oral exam, project presentation, seminars etc.)

*maximum length 1 A4 page

<<<List of subjects

**Course title: Decision Support Systems**

**Teacher(s): Zoran D. Nešić, Miloš Ž. Papić**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

The aim of the course is to provide the necessary knowledge for making business decisions in order for the students to be able to connect the following:

1. Defining user requirements,
2. Generating a database,
3. Creating a knowledge base and
4. Development of decision support systems using modern software tools.

**Learning outcomes**

The student is able to identify relevant procedures related to decision support systems so that he/she independently:

1. Models the requirements
2. Models data and generates the database,
3. Creates a knowledge base and
4. Organizes the architecture and functions of the components of the decision support system.

**Contents**

The place and the role of DSS in decision making; Structure of decision support systems; Classification of decision support systems; Misconceptions, Assumptions, Limitations; Defining user requirements; Modeling business functions; Conceptual (logical) data modeling; Physical modeling of data for selected DBMS; Generating the database; Defining knowledge bases, Defining reasoning mechanism; Development of knowledge base rules; Knowledge engineering and decision making; DSS as integrator of IT and management processes; DSS for executors; Types of users; Analytical databases; Decisions on the basics of the Knowledge Base.

**Recommended literature**


[3] Veljović, A. Management Information Systems, Technical Faculty, Čačak, 2011.

[4] Ramanathan Sugumaran, John Degroote. Spatial Decision Support Systems: Principles and Practices, CRD Press, ISBN 9781420062090 - CAT# 62093, 2010.

[5] Chiang Jao, Decision Support Systems, ISBN 978-953-51-0799-6, 282 pages, Publisher: InTech, Chapters published October 17, 2012 under CC BY 3.0 license

[6] Veljović, A. Visualization of business processes in engineering, Faculty of Technical Sciences in Čačak, 2013.


| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Lectures, consultations, with the realization of theoretical and practical interactive hybrid teaching with cooperative study, research and problem solving in the DSS domain of knowledge.

**Evaluation (maximum number of points 100)**

Prerequisites: 50 points

Final part of the exam: 50 points

Weays of testing the knowledge may vary: (written tests, oral exam, project presentation, seminars etc.)

*maximum length 1 A4 page


<<<List of subjects

**Course title: Electronic Business**

**Teacher(s): Nenad Stefanović, Miloš Papić**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

Equipping students with e-business models, technologies and infrastructure, so they can be trained and capable for planning, designing, implementing and using various e-business systems.

**Learning outcomes**

Acquired theoretical and practical knowledge about electronic business models and systems, as well as their application in practice. Capability to independently plan and realize e-business projects and carry out the related research.

**Contents**

*Theoretical lectures*

E-business models; e-business infrastructure; cloud computing; e-business strategies; organizational structures for e-business; business processes in e-business; internet business plan; e-commerce; e-procurement; Supply Chain Management (SCM); online payment systems; internet marketing; social media; Customer Relationship Management (CRM); information systems; Enterprise Resource Planning (ERP); e-banking; e-government; electronic education; e-health; mobile business; blockchain and cryptocurrencies; business intelligence in e-business; technology trends in e-business; Internet of Things in business; Industry 4.0; ebXML; Semantic Web; Application of data science and artificial intelligence in e-business; security, privacy and ethics in e-business.

*Practical lectures*

Business plan development; e-commerce web site design in leading content management systems; design and programming web applications for e-commerce in various web frameworks. Working in leading e-commerce, ERP and CRM systems (Shopify, Magento, BigCommerce, Salesforce, Dynamics 365, Dynamics Business Central, SAP, SuiteCRM, etc.)

Recommended literature


1. Nenad Stefanovic, Business Intelligence in Complex B2B Networks, Faculty of Science, Kragujevac, 2016.
2. Bozidar Radenkovic et. al., Electronic Business, Faculty of Organizational Sciences, Belgrade, 2015.
3. Information Resources Management Association. (2021). Research Anthology on E-Commerce Adoption, Models, and Applications for Modern Business, IGI Global.
4. Lee, I. (Ed.). (2016). Encyclopedia of E-Commerce Development, Implementation, and Management (3 Volumes). IGI Global.


| Number of active classes | Theory: | Practice: |
|---|---|---|

**Teaching methods**

Combination of classic teaching with e-learning with the appropriate literature. Problem-based learning, practical teaching, independent student work (assignments and projects). Application of modern web services (Office 365) in teaching, communication, teamwork, application development and collaboration. Regular and on-demand consultations both in person and via video conferencing platform.

**Evaluation (maximum number of points 100)**

Pretest - 30 points; project assignment – 40 points; final exam – 30 points.


<<<List of subjects

**Course title: Computer simulation and animation**

**Teacher(s): Vlade D. Urošević**

**Course status: elective**

**Number: 15**

**Condition: None**

**Course objectives**

Introduction to the process and advanced techniques of modeling and simulation. Training for independent modeling and simulation of processes or functions in continuity with previous knowledge in the teaching of computer science.

**Learning outcomes**

The student should develop theoretical and practical knowledge on how to model, analyze and simulate a problem from a real environment or some of the problems within computer science. Students also need to gain knowledge on how to create a user interface and a virtual reality scene.

**Contents**

*Theoretical lectures*

Introduction and historical overview of the development of simulation problems from the real environment. Computer simulation. Types of simulations: Simulation of continuous and discrete systems. Simulation of deterministic, stochastic and mixed systems. Principles of creating a user interface; historical overview of virtual reality; virtual environments - paradigms; applications; input and output devices; Real-time 3D computer graphics. Augmented reality.

*Practical lectures*

Simulation software. Applications of virtual reality in simulation, experiment. Creating virtual reality scenes, simulations, implementation tools (Virtual reality).

Recommended literature

[1] Laplante, P.A. *Real-time Systems Designs and Analysis*, 2nd editions, IEEE Compute Society, 1997.
[2] R Sherman, A Craig, *Understanding Virtual Reality Interface, Aplication, and Design*, The Morgan Kaufmann Series, 2002.
[3] A. Gilat, *Uvod u MatLab 7.5 sa primerima*, Микро књига, 2008.
[4] T. Boardman, *3ds max 6 kroz primere*, Микро књига, 2004.
[5] G. Lewis, J. Lammers, *Maya 5 kroz primere*, Микро књига, 2004.
[6] G Burdea, P Coiffet, *Virtual Realty technology*, 2nd.ed. Wiley, New York, 2003.

| Number of active classes 10 | Theoretical classes: 5 | Practical classes: 5 |
|---|---|---|

**Teaching methods**

Mentoring, project assignment development; study research work, seminar paper, individual work.

**Evaluation** (maximum number of points 100)

Homework - 15

Seminar paper - 35

Oral part of the exam - 50

<<<List of subjects

**Course title: Data Science**

**Teacher(s): Nenad Stefanovic, Marija Blagojević**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

Studying and mastering concepts, methods, techniques, and tools of Business Intelligence (BI), Data Science (DS) and Big Data analytics.

**Learning outcomes**

Acquired knowledge related to business analysis, information systems, data engineering (extract, transfer, load - ETL), dimensional data modelling, data warehouse design, OLAP (On Line Analytical Processing), Data Lakes, Data Mining/Machine Learning, cloud analytics services, Big Data analytics, performance management, reporting and data visualization.

Students gain knowledge and skills for designing intelligent information systems based on data science technologies and tools, as well as application of BI systems in electronic business and various business domains.

**Contents**

*Theoretical lectures*

Basic concepts of Business Intelligence; analysis and modelling of business systems; data warehousing and OLAP; Data Lakes; dimensional data modelling; BI performance tuning; Query languages (MDX, DAX, Python, etc.); real-time BI and business activity monitoring; Python frameworks and libraries for data science; Machine Learning – algorithms, development methods, and applications; performance management (Key Performance Indicators-KPI, Balanced Scorecards); reporting; BI portals; Cloud Analytics; Intelligent services and digital assistants for analytics and decision making.

*Practical lectures*

Case studies in application of intelligent information systems; Design and development of BI systems using adequate software tools and datasets. Working with cloud analytics services and tools. BI modules of leading ERP/SCM/CRM systems (SAP Analytics Cloud, Oracle Business Intelligence, Microsoft Dynamics BI); Big Data analytics (Hadoop, Spark, Pig, Mahout, Hive, HDInsight, Data Lake, Data Factory, Databricks, Azure Synapse Analytics, etc.); Stream Analytics; Excel, Power BI, Tableau tools for data modelling, reporting and visualization. Open-source BI systems and tools.

Recommended literature


1. Nenad Stefanovic, Business Intelligence in Complex B2B Networks, Faculty of Science, Kragujevac, 2016.
2. Has Altaiar, Jack Lee, Michael Pena, Cloud Analytics with Microsoft Azure: Build Modern Data Warehouses with the Combined Power of Analytics and Azure, Packt Publishing, 2019.
3. Ramesh Sharda, Dursun Delen, Efraim Turban, David King, Business Intelligence, Analytics, and Data Science: A Managerial Perspective, Pearson, 2017.
4. Brian Larson, Data Analysis with Microsoft Power BI, McGraw-Hill Education, 2019.
5. C.S.R. Prabhu, Aneesh Sreevallabh Chivukula, Aditya Mogadala, Rohit Ghosh, L.M. Jenila Livingston, Big Data Analytics: Systems, Algorithms, Applications, Springer, 2019.


| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Combination of classic teaching with e-learning with appropriate literature. Problem-based learning, practical teaching, independent student work (assignments and projects). Application of modern web services (Office 365) in teaching, communication, teamwork, application development and collaboration. Regular and on-demand consultations both in person and via video conferencing platform.

**Evaluation (maximum number of points 100)**

Pretest - 30 points; project assignment – 40 points; final exam – 30 points.


<<<List of subjects

**Course title: Applied computer vision**

**Teacher(s): Vladimir M. Mladenovic**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

Preparation for research work in the field of computer vision.

**Learning outcomes**

A student should understand and master the basic knowledge, theories and methods in image processing and computer vision. A student should gather skills to identifiy, formulate and solve problems in image processing and computer vision. Furthermore, a student should gain knowledge of analyzing, evaluating and examining the existing practical computer vision systems. A student is expected to critically review and evaluate the scientific literature in this field and apply theoretical knowledge to identify the novelty and practicality of the proposed methods. A student should also develop skills to design and develop practical and innovative applications or systems for image processing and computer vision. They behave professionally and responsibly in the areas of image processing of the computer vision of deep learning.

**Contents**

*Theoretical teaching*

The course provides an overview of the challenges of computer vision, common approaches and current techniques. The use of specific examples and applications to illustrate, focusing on basic techniques and algorithms. Assuming that students do not have prior knowledge of computer vision, they are introduced to techniques such as the application of deep learning, face recognition and detection, objects, monitoring the results of object calculations and displays on different segments, monitoring semaons and segments.
The reviews of the latest results in the field of computer vision through scientific papers.

*Practical teaching*

Part of the teaching is realized through independent research work in the field of computer vision. Study research work includes active study of scientific literature, organization and performance of experiments, data processing, writing a scientific paper in the scientific field to which the topic of the doctoral dissertation belongs.

**Leterature**


[1] D. Forsyth and J. Ponce, *Computer Vision: A Modern Approach*, 2010.

[2] Witold Pedrycz, Shyi-Ming Chen, *Deep Learning: Algorithms and Applications*, 2020, Springer

[3] S. Khan, H. Rahmani, S. Shah and M. Bennamoun, *A Guide to Convolutional Neural Networks for Computer Vision*, 2018 (online version available from a USC account)

[4] Richard Szeliski, *Computer Vision: Algorithms and Applications*, 2010 (online version available at no cost for personal use)


| Number of classes of active teaching: 7 | Theoretical teaching: 5 | Practical teaching: 2 |
|---|---|---|

**Teaching methods**

Lectures, consultations. Study research.

**Evaluation (maximum number of points 100)**

Homework - 20

Seminar paper - 30

Oral part of the exam - 50


<<<List of subjects

**Course title: Intelligent educational systems**

**Teacher(s): Danijela M. Milošević, Veljko V. Aleksić**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

The aim of the course is to acquaint students with modern advanced concepts, techniques and tools for the development and implementation of intelligent systems in education. The course should enable students to monitor and analyze current research on technological aspects of intelligent educational systems and their application.

**Learning outcomes**

At the end of the course, the student is expected to know and functionally use advanced concepts and technologies for the development of intelligent educational systems; apply appropriate methods and techniques for the creation, testing and implementation of intelligent systems in education; plan and independently implement research in this area.

**Contents**

*Theoretical lectures*

An overview of the areas of technology-enhanced learning (TEL) and the application of intelligent systems in education. Classification, application and theoretical framework of designing intelligent educational systems. User modeling, personalization and adaptability. Development of self-regulated and social learning in the digital environment. Virtual Learning Environments (VLE). Learning analytics. Game-Based Learning (GBL). Mobile technologies and learning (M-Learning). Massive Open Online Courses (MOOC) and Open Educational Resources (OER). Intelligent tutors and personal agents. Patterns of user behavior and pedagogical aspects (learning theories and instructional design). Interoperability, metadata and standards. Scalability and integration of intelligent educational systems.

*Practical lectures*

Mastering the techniques of development and integration of intelligent educational systems via project development and working with digital tools and systems in the computer laboratory.

**Recommended literature**


[1] Kinshuk, D.: Designing Adaptive and Personalized Learning Environments. Routledge, 2016. doi:10.4324/9781315795492

[2] Clark, R., Mayer, R.: E-learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning. San Francisco: Pfeiffer, 2016.

[3] Aleksić, V.: Educational technology in the digital domain. Čačak: Faculty of Technical Sciences, 2021.

[4] Nystrom, R.: Game programming patterns. Genever Benning, 2014.

[5] Barkley, E.: Student Engagement Techniques: A Handbook for College Faculty. San Francisco: Jossey-Bass, 2010.


| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Presentations and practical study examples related to certain techniques, development environments and software tools. Working with digital tools and environments in the laboratory and development of independent projects in the field of intelligent educational systems.

**Evaluation (maximum number of points 100)**

Activities during the lectures: 10 points;
Project development and presentation: 40 points;
Oral part of the exam: 50 points


<<<List of subjects

**Course title: Protection of Computer Systems**

**Teacher(s): Marjan D. Milošević**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

Introduction of modern features of computer systems' protection. Upgrading previously acquired knowledge in the field of data protection and security of networked systems. Introducing to research methodology in the area of information-communication systems security.

**Learning outcomes**

The student is capable of analysing threats and modern protection methods on various levels (application, operating systems, network infrastructure). Student individually models threats in the Internet of Things and Cloud Computing environment.

The student can use knowledge sources in the area of information security and upgrade existing concepts and solutions. The student can apply current programming paradigms to develop protection solutions and protection mechanism assessments. The student applies scientific methodology in the research of computer systems protection.

**Contents**

*Theoretical lectures*

Security policies and mechanisms. Standardisation. Perimeter security. Cryptography-based protection methods. Security protocols. Zero-knowledge. Security of networked systems, Internet of things and cloud. Advanced intrusion detection methods. Anonymity and privacy protection. Blockchain application in computer system protection. Usability of the protection software and systems. Review of the latest results in the research of the area.

*Practical lectures*

Teaching is partly implemented via individual research in the area of information security. Research study work involves active studying of scientific literature, design of protection systems, organisation and conducting of measurement and testing, data collection and processing, and writing scientific papers in the area of information security.

**Recommended literature**


[1] R. Anderson, *Security Engineering: A Guide to Building Dependable Distributed Systems*, Wiley, Indianapolis, 2020

[2] M.H. Bhuyan, D. K. Bhattacharyya, J.K. Kalita, *Network Traffic Anomaly Detection and Prevention: Concepts, Techniques, and Tools*, Springer International Publishing AG, Cham, 2017.

[3] Martin K., *Everyday Cryptography Fundamental Principles and Applications*, Oxford University Press, Oxford, 2017

[4] Scientific journals (Computers and Security, Journal of Information Security and Applications, IEEE Security and Privacy, ACM Transactions on Privacy and Security…)


| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methodology**

Presentation, case study, practical work, study research work

**Evaluation (maximum number of points 100)**

Ways of testing the knowledge:

Homework- 20

Project - 30

Oral exam- 50

*maximum length 1 A4 page


<<<List of subjects

**Course title: Contemporary Modern network technologies**

**Teacher(s): Vladimir M. Mladenovic**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: Knowledge of computer networks at the level of undergraduate studies is desirable, as well as knowledge of Python or Java programming languages**

**Course objectives**

The aim of the course is to learn in detail the principles and mechanisms of management of both classic computer networks and modern communication networks. Introduction to the mechanisms and methodology of modern computer systems management, which today includes complex activities on the boundaries between organizational management methods, software design components for traditional network management and wireless network management aspects. This is an area that is intensively developing and which is of special importance for the data center and the provision of various services with large data protocols. The course includes selected chapters of modern networks such as 4G and 5G, as well as Defined Networking Software (SDN).

**Learning outcomes**

Students gain knowledge about today's functioning, analysis and management of computer networks, which are current areas of research and potential development. The student is capable of managing and planning computer networks, either by developing applications that support individual processes of managing networks and network services.

**Courses**

*Theoretical teaching*

Review of the latest results in the field of computer vision through scientific papers.
Students get acquainted with new communication networks, their management, standards, ways of centralized and distributed management of computer networks, management of multi-domain network services, autonomous support. Students get acquainted with modern concepts of mobile 4G and 5G, as well as SDN, key research topics in these areas. They follow the trends of development and application of new communication networks, topologies and ways of protection of centralized and distributed management of computer networks, concepts of time network technologies, ways of their design, development and upgrade, apply global aspects of standardization of network technologies (new ISO / IEC projects). Potential directions of new research, top performance testing.

*Practical teaching*

Analysis and simulation of computer network performance through solving specific project problems.

**Literature**

[1] Nadeau T., Gray K., SDN: Software-Defined Networks, O'Reilly Media, 2013.
[2] http: //www.cse.vustl.edu/~jain/cse570-13/ Online courses
[3] A set of scientific papers in relevant fields
[4]. Rodriguez, 5G Mobile Network Basics, 2015, John Viley & Sons, Ltd.

| Number of classes of active teaching: 3 | Theoretical teaching: 2 | Practical teaching: 1 |
|---|---|---|

**Teaching methods**

Lectures, consultations. Study research.

**Evaluation (maximum number of points 100)**

Seminar paper - 20

Experimental research work with presentation - 30

Oral exam- 50

<<<List of subjects

**Course title: Information Systems Development**

**Teacher(s): Miloš Ž. Papić**

**Course status: elective**

**Number of ECTS credits: 10**

**Condition: None**

**Course objectives**

The aim of the course is the acquisition of the knowledge necessary to students to be able to work successfully in the object-oriented domain of information systems design and development. They will be able to connect and use UML standards with classical standards for functional and information modeling.

**Learning outcomes**

Ability to use modern techniques, tools and methodologies of IS design and development in object-oriented domain. Gaining a complete picture of how IS development is realized, from defining requirements, through analysis, design to implementation.

**Contents**

*Theoretical lectures*

The order of presenting the topics is in accordance with the standardized phases, concepts and activities in the process of IS design and development, using the appropriate CASE tool, as specialized software in IS design and development. Defining user requirements, Object Oriented Analysis, Object Oriented Design and Object Oriented Implementation. Defining application and network architecture technology. Testing. Introduction. Maintenance.

*Practical lectures*

Exercises follow lectures (theoretical classes) through object-oriented concept and development of: logical model of functions, physical model of business processes, conceptual model and diagrams (sequences, collaborations, complete class diagrams, state diagrams, etc.). Application development.

**Recommended literature**


[1] Veljović, A., Development of information systems, Technical Faculty Čačak, Čačak, 2011.

[2] Ilić, S., Veljović, A. Software design with databases in UML, Faculty of Technical Sciences in Kosovska Mitrovica and Faculty of Technical Sciences in Čačak, 2017. ISBN: 978-86-7776-207-0

[3] Booch, G., Rumbaugh, J., Jacobson, I. UML User Guide, Belgrade: CET, 2000. ISBN: 978-86-7991-111-9

[4] Veljović, A., Papić, M. (2020). Analysis and design of information system in practice, Čačak: Faculty of Technical Sciences, ISBN: 978-86-7776-244-5


| Number of active classes: 7 | Theory: 5 | Practice: 2 |
|---|---|---|

**Teaching methods**

Lectures, consultations, with the realization of theoretical and practical interactive hybrid teaching with cooperative study, research and problem solving in the field of production information systems.

**Evaluation (maximum number of points 100)**

Prerequisites: 50 points

Final part of the exam: 50 points

Ways of testing the knowledge may vary: (written tests, oral exam, project presentation, seminars etc.)

*maximum length 1 A4 page


<<<List of subjects

**Course title: Scientific-research project 1**

**Teachers: Mentor**

**Status:** Compulsory

**ECTS credits: 15**

**Prerequisites: none**

**Course objectives:**

The key goal of the course is to introduce new concepts in the field of students' scientific interest. Other goals are to assist students to acquire the following skills (by using a scientific platform or independently):

1) Analysis & Problem-Solving (within their Doctoral thesis framework, if applicable) toward scientific research papers production and publication;
2) Application of basic Methods, Techniques, Tools, Theoretical and methodological knowledge, Scientific and professional know-how, and use of cutting-edge research from the relevant literature in the field of interest;
3) Independent assessment and discussion of research results;
4) Written and Oral communication, using argumentative, cohesive structures, and by application of different methods and results of the original scientific research in the scientific field of interest.

**Learning outcomes:**

Upon completion of this course the student will have reliably demonstrated the ability to (independently):

1) design research;
2) use relevant resources and referential literature by application of relevant methods; to transfer knowledge from one course to another; to produce original research results and research studies which significantly broaden our current knowledge in the field of interest;
3) systematically analyze and bring relevant conclusions;
4) publish and report the results of their scientific research (within the planned PhD thesis framework), argue and comment on their significance, and provide a contribution to further research;
5) provide public evidence of independent and systematical understanding of the scientific and professional papers; elaborate in an argumentative manner on the research conducted, present original research results to a wider scientific community (national and international conferences).

**Contents:**

***Theoretical classes:***

***Practical classes – Independent scientific paper***

1) The structure of the research is formed individually compliant with the research topic and the objectives of the doctoral thesis, and the previously defined goals. The doctoral student studies the professional and theoretical literature, analyzes the course and makes correlations with their thesis, in order to come up with a solution to a specific problem, which was previously set by their PhD mentor.
2) Papers are (as a rule) written within the planned topic of the doctoral dissertation. Compliant with the themes of a particular conference (national or international), and/or journals published at the national and international level. During scientific article/paper paper writing, the doctoral student uses relevant literature and applies the methodological framework.
3) After writing the papers, there is a review process and possible corrections before the publication of the papers (scientific and professional articles).
4) After the positive evaluation of the papers is obtained, the doctoral student is allowed to defend the papers. After presenting the results and defending the papers, the candidate answers the questions.

**Recommended literature:**

-

| | | |
|---|---|---|
| Number of active classes: 0 | Theoretical classes: 0 | Practical classes - IRP: 10 |

**Teaching methods:**

Public, oral (viva) defense, with the application of the multimodal tools, while presenting the original research papers.

**Evaluation (max points 100)**

Writing and submission of paper(s) - 50; Paper(s) publication - 50.

<<<List of subjects

**Course title: Scientific-research project 2**

**Teachers:** Mentor

**Status:** Compulsory

**ECTS credits: 15**

**Prerequisites:** none

**Course objectives:**

The key goal of the course is to introduce new concepts in the field of students' scientific interest. Other goals are to assist students to acquire the following skills (by using a scientific platform or independently):

1) Analysis & Problem-Solving (within their Doctoral thesis framework, if applicable) toward scientific research papers production and publication;

2) Application of basic Methods, Techniques, Tools, Theoretical and methodological knowledge, Scientific and professional know-how, and use of cutting-edge research from the relevant literature in the field of interest;

3) Independent assessment and discussion of the research results;

4) Written and Oral communication, using argumentative, cohesive structures, and by application of different methods and results of the original scientific research in the scientific field of interest.

**Learning outcomes:**

Upon completion of this course the student will have reliably demonstrated the ability to (independently):

1) design research;

2) use relevant resources and referential literature by application of relevant methods; to transfer knowledge from one course to another; to produce original research results and research studies which significantly broaden our current knowledge in the field of interest;

3) systematically analyze and bring relevant conclusions;

4) publish and report the results of their scientific research (within the planned PhD thesis framework), argue and comment on their significance, and provide a contribution to further research;

5) provide public evidence of independent and systematical understanding of the scientific and professional papers; elaborate in an argumentative manner on the research conducted, present original research results to a wider scientific community (national and international conferences).

**Contents:**

**Theoretical classes:**

**Practical classes – Independent scientific paper**

1)The structure of the research is formed individually, compliant with the research topic and the objectives of the doctoral thesis, and the previously defined goals. The doctoral student studies the professional and theoretical literature analyzes the course and makes correlations with their thesis, in order to come up with a solution to a specific problem, which was previously set by their PhD mentor.

2)Papers are (as a rule) written within the planned topic of the doctoral dissertation. Compliant with the themes of a particular conference (national or international), and/or journals published at the national and international level. During scientific article/paper paper writing, the doctoral student uses relevant literature and applies the methodological framework.

3) After writing the papers, there is a review process and possible corrections before the publication of the papers (scientific and professional articles).

4) After the positive evaluation of the papers is obtained, the doctoral student is allowed to defend the papers. After presenting the results and defending the papers, the candidate answers the questions.

**Recommended Literature:**

-

| | | |
|---|---|---|
| Number of active classes: 0 | Theoretical classes: 0 | Practical classes - IRP: 10 |

**Teaching methods:**

Public, oral (viva) defense, with the application of the multimodal tools, while presenting the original research papers.

**Evaluation (max points 100)**

Writing and submission of paper(s) - 50; Paper(s) publication - 50.

<<<List of subjects

**Course title: Doctoral thesis (theoretical foundations)**

**Teacher(s): Mentor**

**Status:** Compulsory

**ECTS credits: 30**

**Prerequisites:** (Minimum) one published paper of the candidate in the field of doctoral thesis

**Course objectives:**

1) Students are guided to recognize an existing problem (or a burning issue) in the specific scientific field, based on a previously conducted analysis and research, so that they can contribute to its solving.
2) Students are prepared to conduct independent research within their doctoral thesis production.
3) Supervised by their mentors, students are instructed to learn how scientific contribution is achieved, while at the same time being taught how to deploy complex scientific-research methods and instruments, and how to apply the acquired skills and knowledge in their work.
4) The final goal is the scientific contribution, i.e. realization of a solution created as an outcome of the scientific research.

**Learning outcomes:**

Upon the completion of the course, the student is capable of:

1) recognizing an existing problem (or a burning issue) in the specific scientific field, based on a previously conducted analysis and research, so that they can contribute to its solving. They are capable of using the normative rules in designing scientific methodology, drawing research hypotheses and describing the prospective research results. Also, they are capable of predicting the potential scientific contribution of their work. They acquire skills to approach a problem in an adequate manner, argue on their choices of tools and methods, design a research proposal within a timeframe, create tentative contents of their paper and the expected results, as well as deal with the relevant literature used in the research.
2) conducting independent research in a chosen scientific field. The candidate is capable of searching for the relevant literature and resources, analyzing it and providing a review/summary of the contemporary scientific approaches and solutions to the problem.
3) applying the basic principles of the scientific evaluation of the existing solutions
4) predicts the shortcomings and benefits of such solutions, based on the preceding research methods.

**Course contents:**

***Theoretical classes:***

After candidates pass all the examinations, they decide on their mentor, who is chosen upon the previous consultation with the PhD studies Committee. The mentor provides support for the candidates' IRP production, in laboratory conditions or in a research center/institute.

***Practical classes:***

Students conduct research within the scope of their scientific interest. The contents of their particular work depend on the selected field of scientific interest.

Students are supposed to:

1- identify a current problem within the specific scientific field of their choice, which they recognize as a potential topic for conducting independent research, along with elaborating on the results/goals of the potential research.
- Present a form of a novel scientific contribution (new model, new technology, new approach etc.)
- Present research hypotheses and the potential research results.
- List the basic methods of research they will use while solving a problem, and elaborate on their choice.
- Describe the research design and the research phases, the use of research methods in certain parts of the research, with the timeframe of its finalization.
- Elaborate on the tentative paper contents and its results (section levels in chapters as a minimum requirement, the third level in the hierarchy is desirable).
- Select the resources and literature that will be used in the research.

2- demonstrate extensive knowledge and understanding of the problem that emerges in the specific scientific field they have been studying, so that they are able to write a review of the said issues in the specific scientific field, as well as the current solutions to the problem.

3 - Provide an overall understanding of the said problems and solutions, and assess them critically and in an argumentative manner.

**Recommended Literature:**

[1] ...

| | | |
|---|---|---|
| Number of active classes: 0 | Theoretical classes: 0 | Practical classes - IRP: 20 |

**Teaching methods:**

The Rulebook on Doctoral Studies of the University of Kragujevac contains detailed procedures for applying for a doctoral thesis. After consulting a potential mentor, the candidates submit a Doctoral thesis proposal (with a

| |
|---|
| broader research topic) to the Scholarly Board. The council evaluates the suitability of the topic and appoints a mentor. After the topic proposal is approved, the student conducts research in a laboratory or a research center under the supervision of the mentor, using the literature list provided by the mentor. Periodically, in consultation with the mentor, the student's progress is checked and additional guidance is provided. If necessary, candidates conduct measurements and lab examinations, or statistical data analysis. |
| **Evaluation (maximum points 100)**<br>Conducted measurements and lab examinations - 50;<br>Documented verification of the conducted measurements and lab examinations – Doctoral thesis proposal approved - 50. |

<<<List of subjects

**Course title: Doctoral thesis - Scientific-research project**

**Teacher or teachers:** Mentor

**Status:** Compulsory

**ECTS credits: 30**

**Prerequisites: Doctoral thesis (theoretical foundations)**

**Course objectives**

The aim of this course is to enable students to:

1) indipendently recognize and search for adequate research frameworks, which implies the selection of relevant up-to-date literature;
2) independently integrate theoretical elements of relevant research frameworks and adequate methods when conducting research;
3) carry out critical analysis and adequately prepare various multivariate procedures;
4) independently write and present research results.

**Learning outcome**

Upon completion of the course, the student will have developed the ability to:

1) independently identify possible research problems,
2) carry out the research regarding the identified problem; show independence in statistical data processing; independently search for relevant literature necessary for the research,
3) critically analyze the results,
4) independently write a scientific paper for publication in a journal of the required level (according to the bylaws).

**Contents**

***Practical classes - work on Independent research project***

1) The student conducts independent research that is directly related to the topic of the doctoral thesis.
2) The doctoral student thinks critically and acts creatively and independently.
3) The final part of the project is writing a scientific paper that will be accepted for publication in one of the journals from the SCI journal list.
4) The candidate prepares a paper in a form that contains the following chapters:
   Introductory part (with the subject of the paper, objective);
   Theoretical and methodological part;
   Research part;
   Results and Discussion;
   Concluding remarks;
   Literature review (and appendices if any).

**Recommended literature**

[1] ...

| Number of active classes: 0 | Theoretical classes: 0 | Practical classes - IRP: 20 |
|---|---|---|

**Teaching methods:**

Mentoring, Independent research project of the candidate/doctoral student, independent literature research, research work, consultations with the mentor or other relevant experts, independent writing of a scientific paper.

**Evaluation (max points 100)**

Documented verification of measurements and tests – a scientific paper accepted for publication in one of the journals from the SCI journal list
- 100.

<<<List of subjects

**Course title: Doctoral Thesis-production and defense**

**Teacher(s): Mentor**

**Course status: compulsory**

**Number of ECTS credits: 30**

**Condition: Defined by the acts of law and bylaws**

**Course objectives**

The main objective of the course is the production (writing) and defense of the final paper (doctoral thesis) on the specified topic.

One of the objectives is also an application of fundamental, theoretical and methodological, scientific and professional as well as the professional and applicative knowledge, methods and the innovative information presented in the relevant scientific and expertise literature when students of doctoral studies start resolving concrete problems.

Objectives also include:

Writing of the doctoral thesis;

Public oral presentation in the corresponding field with proper knowledge and systematic understanding;

The ability of independent and argumentative presentation of the methodology applied and the results of the original scientific reserch with the necessary digree of academic integrity, with clear, concise and argumentative answers on the question posted by the commission for the doctoral thesis defense.

**Learning outcomes**

**The student of doctoral studies is expected to have the following proven abilities to:**

apply the corresponding methodologies and transfer innovative knowledge in the field of the dissertation topic,

independently present the applied methodology and the results of their original scientific research to the members of scientific public with the corresponding degree of academic integrity,

independently use relevant literature applying scientific methodology,

use systematic analyses and reach relevant conclusions in order to present the results of their research on the specified topic of the doctoral thesis, to enlarge on their significance and contribution to further scientific research in the corresponding field,

provide original scientific and research results which broaden the boundaries of the existing knowledge in the scientific field of the thesis,

answer clearly, concisely and argumentatively on the questions posted by the members of the commission for the doctoral thesis defense.

Public verification of knowledge and systematic understanding of the doctoral thesis subject.

**Course subject**

***Theoretical classes***

Theoretical foundations represent the necessary condition for successful development, writing and defense of the doctoral thesis.

***Practical classes***

The contents of the doctoral thesis is original and it is in accordance with the subject and purpose of the paper. A student has conducted literature review, analysed the subject of the thesis in order to find the appropriate solutions to the task and undertaken thesis development.

***Writing doctoral thesis***

The mentor and the candidate mutually design the framework of the doctoral thesis and the candidate accepts and applies it in their thesis.

The doctoral thesis is developed (and documented) within the framework of the approved topic which contains the defined aims, tasks, hypotheses that have been previously defined by the Commission for the assessment of the competence of the theme, the candidate and the mentor (the thesis proposal verified by the University of Kragujevac as a proposal of the Scolarly Board of the Faculty of Technical Sciences).

Positive review of the doctoral thesis theme enables a candidate to start the description of the results obtained by preparing the doctoral thesis.

In the process of preparing the thesis, a candidate consults a mentor about the additional instructions, contemporary literature and further directions with the aim of creating a quality doctoral thesis.

Depending on the topic and the requirements of the thesis a candidate does projects, surveys, research, statistical calculations, creates (software) applications whose results are further incorporated into the dissertation.

The student of doctoral studies uses relevant literature proposed and analysed together with a mentor.

The candidate can consult other subject specialist teachers concerning the topic of the thesis.

The candidate is obliged to pass all the exams that were defined by the study program before they submit the thesis.

***The defense of the doctoral thesis***

Public presentation of the doctoral thesis is organized according to the Rulebook on doctoral studies and admition to the Phd degree on the Faculty of Technical Sciences in Čačak.
After a process of documentation has been finished, the candidate (according to the abovementioned Rulebook) in collaboration with the mentor submits the suitable number of dissertation samples. The Scholarly Board of the Faculty of Technical Sciences decides upon the Commission for the evaluation and defense of the doctoral thesis which consists of at least three members.

The Commission delivers the report (positively reviewed) to the Scholarly Board of the Faculty of Technical Sciences for the purpose of evaluation. The report is further reviewed and submitted to the Univeristy of Kragujevac to be accepted. Thus, positively reviewed and accepted report on the evaluation of the doctoral thesis is brought back to the Faculty of Technical sciences and the Commission, together with the Dean and the candidate, sets the date for the oral presentation of the doctoral thesis.

The oral defense of the thesis comprises a brief overview of the thesis, the presentation of the results and scientific contribution of the dissertation. The candidate further answers the questions posted by the members of the Commission. The defense has finished when all the members of the Commission have asked their questions and the candidate provides suitable answers.
After the Commission has finished the defense report, it informs the candidate on the result of the defense. The defense report is further submitted to the administration of the Faculty of Technical Sciences and the University.

A positively reviewed report provides the promotion of the doctoral studies candidate, when all the candidates who have been admitted to the degree of the doctors of sciences on the University of Kragujevac.

**Recommended literature**

[1] ...

| | | |
|---|---|---|
| Number of active teaching classes: 0 | Theoretical classes: 0 | Practical classes – OTHER : 20 |

**Teaching methods**

Public oral presentation, multimedia methods in presenting the independent and original results of the scientific research on the specified topic of the doctoral thesis.

**Evaluation (maximal number of points 100)**

Preparation of the doctoral thesis -50
Defense of the doctoral thesis - 50.

<<<List of subjects