FACULTY OF INFORMATICS AND DIGITAL TECHNOLOGIES
UNIVERSITY OF RIJEKA

CURRICULUM OF THE GRADUATE UNIVERSITY STUDY PROGRAMME

INFORMATICS

Rijeka, 2022

1. INTRODUCTION

A year after the establishment of the Department of Informatics, University of Rijeka in 2009, in addition to the two teaching-oriented graduate programmes, a general programme was launched with the aim of training personnel for employment in the economy - the **Graduate University Study Programme Informatics.**

However, the history of studying informatics at the University of Rijeka dates back even further. Starting from 1975, it was first carried out as a two-year, and later as a four-year study programme in Informatics at the then Faculty of Industrial Education. In the year 1984/1985, the study programme in mathematics and informatics was launched at the then Faculty of Education, where the Institute for Informatics was founded in 1987. Its aim was to bring together all the material from the field of informatics and to modernise the teaching content for this study programme by applying information technology. The Institute for Informatics was renamed Department of Informatics in 1994. First it formed part of the Faculty of Education, and since 1998 of the newly founded Faculty of Humanities and Social Sciences in Rijeka. In the academic year 1999/2000, a double-major study programme in Informatics was launched. It was designed as an open programme that could be combined with other study programmes at the Faculty of Humanities and Social Sciences such as philosophy, history, pedagogy, English language, German language etc. In 2004, a double-major in physics and informatics was also launched. A permit for the independent single-major undergraduate study programme in Informatics, aligned with the principles of the Bologna process, was issued in the academic year 2005/2006. After the Department of Informatics, University of Rijeka was founded in 2008, all permits for carrying out the said study programmes held by the former department at the Faculty of Humanities and Social Sciences were transferred to the Department as its legal successor.

By decision of the Commercial Court in Rijeka (Tt-21/6193-10, dated December 31, 2021), the name of the Department of Informatics was changed to the **Faculty of Informatics and Digital Technologies**.

The Faculty of Informatics and Digital Technologies of the University of Rijeka strives to profile itself as a leading higher education institution in the field of information and communication sciences in the region, providing high quality and efficient education aimed at achieving the desired skills and competencies of students and their high employability. For this reason, the faculty strives to continuously improve the Informatics graduate study program and constantly modernize the teaching content in accordance with the trends and requirements of the profession and the needs of the market, taking into account compliance with HKO standards and internationally recognized standards. In the teaching processes, they try to incorporate scientific achievements and innovative methods of scientific and development research, which the employees carry out in cooperation with researchers from Europe and with entrepreneurs from the wider region. Outcomes at the degree level have focused on the development of generic competencies such as academic literacy, presentation and communication skills, and independent solving of complex problems in computer science, as well as the promotion of professional standards and ethics in the profession and the promotion of socially responsible behavior.

This version of the program includes two compulsory subjects (Master's thesis and Internship in the last semester) and elective modules that students choose according to their preferences and interests. The modules are:

- Inteligent and interactive systems (IIS)
- Business informatics (BI).

Each student chooses a module upon enrollment and thus specializes in the chosen area of informatics. The program also includes a number of common electives that allow students to acquire additional knowledge and skills, particularly in multimedia systems and communication and computer systems. This is done in areas that cover two of the four modules in the 3rd year of the undergraduate study of Informatics conducted by the faculty, which are not represented to a greater extent by the compulsory subjects of the modules in the graduate programme.

In addition to the electives from the group of common electives, students are also offered the opportunity to take the compulsory subjects of the second module as electives, which significantly increases the number of electives. In addition, students can choose one elective each from the group of common electives with UNIRI or micro-qualifications associated with the program in the 1st and 2nd semesters.

2. DESCRIPTION OF THE STUDY PROGRAMME

2.1. LIST OF COMPULSORY AND ELECTIVE COURSES AND/OR MODULES WITH THE NUMBER OF CLASS HOURS REQUIRED FOR THEIR IMPLEMENTATION AND THE NUMBER OF ECTS CREDITS

LIST OF MODULES/COURSES							
Semester: I.							
MODULE	COURSE	COURSE INSTRUCTOR	L	E	S	ECTS	STATUS
IIS	Applied Multivariate Data Analysis for Computer Scientists	Prof. Maja Matetić, PhD	30	30	0	6	C
IIS	Data Mining	Prof. M. Matetić, PhD / Assoc. prof. M. Brkić Bakarić, PhD	30	30	0	6	C
IIS	Big Data Infrastructure	Assist. Prof. Vedran Miletić, PhD	30	30	0	6	C
IIS	Programming for Artificial Intelligence	Prof. Ana Meštrović, PhD	30	30	0	6	C
IIS	Elective course (from the BI module /common electives/common electives at UNIRI/programme-related micro-qualifications)					6	E
BI	Electronic Commerce and Digital Innovations	Assist. Prof. Danijela Jakšić, PhD	30	30	0	6	C
BI	Non-relational and Distributed Databases	Full Prof. Patrizia Poščić, PhD	30	30	0	6	C
BI	Information Security and Blockchain Technologies	Assoc. Prof. Božidar Kovačić, PhD	30	30	0	6	C
BI	Quantitative Methods for Business Decision Making	Assist. Prof. Martina Holenko Dlab, PhD	30	30	0	6	C
BI	Elective course (from the IIS module /common electives/common electives at UNIRI/programme-related micro-qualifications)					6	E
Common elective courses:							
IIS/BI	Complex Networks Analsis	Prof. Ana Meštrović, PhD	30	30	0	6	E
IIS/BI	E-learning for Education and Business	Prof. N. Hoić-Božić, PhD	30	30	0	6	E
IIS/BI	Distributed Processing in Heterogeneous Systems	Assoc. Prof. Božidar Kovačić, PhD	30	30	0	6	E
Semester: II							
IIS	Machine and Deep Learning	Assoc. Prof. Marina Ivašić-Kos, PhD	30	30	0	6	C
IIS	Big Data Analytics	Prof. Sanda Martinčić-Ipšić, PhD	30	30	0	6	C

IIS	Knowledge Representation and Reasoning	Prof. Ana Meštrović, PhD	30	30	0	6	C
IIS	Elective course (from the BI module or common electives)		2	2	0	6	E
IIS	Elective course (from the BI module /common electives/common electives at UNIRI/programme-related micro-qualifications)					6	E
BI	Software Engineering	Assoc. Prof. Sanja Čandrlić, PhD	30	30	0	6	C
BI	Digital Marketing	Assist. Prof. Danijela Jakšić, PhD	30	30	0	6	C
BI	Managing Digital Transformation	Full Prof. Patrizia Poščić, PhD	30	30	0	6	C
BI	Elective course (from the IIS module or common electives)		2	2	0	6	E
BI	Elective course (from the IIS module /common electives/common electives at UNIRI/programme-related micro-qualifications)					6	E
Common elective courses:							
IIS/BI	3D Computer Modelling	Assist. Prof. Martina Holenko Dlab, PhD	30	30	0	6	E
IIS/BI	Development of 3D games	Assist. Prof. M. Pobar, PhD	30	30	0	6	E
IIS/BI	Interaction Design	Assoc. Prof. Sanja Čandrlić, PhD	30	30	0	6	E
IIS/BI	Computer Forensics	Assist. Prof. Vanja Slavuj, PhD	30	30	0	6	E
IIS/BI	Analysis of Sensor Data	Prof. Maja Matetić, PhD	30	30	0	6	E
Semester: III							
IIS	Intelligent Information Systems	Prof. Sanda Martinčić-Ipšić, PhD/Assist. Prof. M. Pobar, PhD	30	30	0	6	C
IIS	Soft Computing	Assoc. Prof. Marina Ivašić-Kos, PhD	30	30	0	6	C
IIS	Elective course (from the BI module or common electives)					18	E
BI	Business Communication and Communication Technologies	Full Prof. Patrizia Poščić, PhD	30	30	0	6	C
BI	Information Systems Strategic Planning	Assoc. Prof. Sanja Čandrlić, PhD	30	30	0	6	C
BI	Predictive Analytics	Prof. Sanda Martinčić-Ipšić, PhD	30	30	0	6	C
BI	Elective course (from the IIS module or common)					12	E

Common elective courses:							
IIS/BI	Virtual and Augmented Reality	Prof. N. Hoić-Božić, PhD	30	30	0	6	E
IIS/BI	Interactive Web Technologies	Assist. Prof. Lucia Načinović Prskalo, PhD	30	30	0	6	E
IIS/BI	Applied Learning Analytics	Assoc. Prof. Božidar Kovačić, PhD / Assist. Prof. Vanja Slavuj, PhD	30	30	0	6	E
IIS/BI	Business Simulation	Assoc. prof. M. Brkić Bakarić, PhD	30	30	0	6	E
IIS/BI	Computer Vision	Assoc. Prof. Marina Ivašić-Kos, PhD	30	30	0	6	E
IIS/BI	Natural Language Processing Methods	Prof. Sanda Martinčić-Ipšić, PhD	30	30	0	6	E
IIS/BI	Man Machine Communication	Prof. Ivo Ipšić, PhD	30	30	0	6	E
Semester: IV							
IIS/BI	Internship	Prof. N. Hoić-Božić, PhD				6	C
IIS/BI	Graduation Thesis					24	C

2.2. COURSE DESCRIPTION

General information		
Course instructor	Prof. Maja Matetić, PhD	
Name of the course	**Applied Multivariate Data Analysis for Computer Scientists**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objectives of the course include introducing to procedures for summarizing and visualizing different types of data and identification of appropriate data analytics methods, understanding the basic mechanisms of multivariate models and their evaluation and interpretation, use of analytical tools and state of the art program support in practice. The aim of the course is to further examine the mathematical foundations of the numerical algorithms used and to investigate their use through practical examples in various domains of application.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Perform multivariate exploratory data analysis.

O2. Explain the characteristics and properties of the multivariate normal distribution. Describe the concept of relationships of multidimensional data through correlation.

O3. Design simple scripts for data processing, analysis and visualization using data analysis tools.

O4. Check prerequisites, set hypotheses, perform and interpret the results of the application of the following analytical methods on multidimensional data: multiple regression, principal component analysis, factor analysis, discriminant analysis, multidimensional scaling, clustering, network analysis.

O5. Explain and analyze the problem of instability of numerical calculation.

O6. Analyze the complexity and accuracy of algorithms for solving problems of numerical analysis, such as solving a nonlinear equation, finding the extrema of a nonlinear real function of several variables, finding an interpolation polynomial, efficient calculation of polynomial values, numerical derivation and integration.

O7. Implement given numerical algorithms from the field of multivariate statistics and artificial intelligence in a programming language (eg R, Python).

O8. Critically interpret the results of multivariate data analysis and implement an individual multivariate data analysis project in a suitable computer statistical environment.

1.4. Course content

The course includes the following topics:

- Multivariate data and multivariate statistical methods. Multivariate visualizations.
- Multivariate normal distribution. Properties of distributions.
- Correlation coefficients and application. Analysis of variance. Multiple and multivariate regression.
- Dimension reduction. Principal component analysis. Factorial and discriminant analysis. Classification.

- Grouping. Multidimensional scaling.
- Floating point arithmetic. Stability of algorithms.
- Direct methods for solving linear systems. Polynomial interpolation.
- Numerical integration and derivation. Linear least squares problem.
- Numerical solution of nonlinear equations.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will work independently or as a team on a project assignment.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes and participate in all course activities and follow notifications related to classes in the e-learning system.
- Take the final exam and score at least 50% on it.
- Students' obligations include homework, colloquiums, seminars and project assignments.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[1]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

• Comprehension of the theoretical part of the course will be evaluated in the form of an online knowledge test (O2, O5, O6), for example multiple choice questions, supplementary questions.
• In the framework of practical work (exercises, tests and homework), the knowledge of the application of multivariate analysis methods and the mathematical foundations of numerical algorithms (O1, O3, O4, O7) will be continuously evaluated, for example performing the Principal Component Analysis and interpreting the results.
• As part of the final exam, students work on an individual or team project task of applying multivariate data analysis and create documentation and present the results (O4, O7, O8), for example applying the clustering procedure on a given set of data with interpretation of the results.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Härdle, Wolfgang Karl, and Léopold Simar. Applied multivariate statistical analysis. Springer Nature, 2019.
2. James, Gareth, Daniela Witten, Trevor Hastie, and Robert Tibshirani. An introduction to statistical learning with applications in R. Vol. 112. New York: Springer, 2021.

[1] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

3. Bloomfield, Victor A. Using R for numerical analysis in science and engineering. Chapman and Hall/CRC, 2018.
4. Greenbaum, Anne, and Tim P. Chartier. Numerical methods: design, analysis, and computer implementation of algorithms. Princeton University Press, 2012.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Everitt, Brian, and Torsten Hothorn. An introduction to applied multivariate analysis with R. Springer Science & Business Media, 2011.
2. Johnson, Richard Arnold, and Dean W. Wichern. Applied multivariate statistical analysis. Vol. 6. London, UK:: Pearson, 2014.
3. Denis, Daniel J. Univariate, Bivariate, and Multivariate Statistics Using R: Quantitative Tools for Data Analysis and Data Science. John Wiley & Sons, 2020.
4. G. Tabachnick, L.S. Fidell, Using multivariate statistics, 6th Edition, Pearson, 2018.
5. Hair J.F. et al. Multivariate Data Analysis, 7th Edition, Pearson , 2014.
6. Wickham, Hadley, and Garrett Grolemund. R for data science: import, tidy, transform, visualize, and model data. " O'Reilly Media, Inc.", 2017.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Härdle, Wolfgang Karl, and Léopold Simar. Applied multivariate statistical analysis. Springer Nature, 2019.	2	20
James, Gareth, Daniela Witten, Trevor Hastie, and Robert Tibshirani. An introduction to statistical learning with applications in R. Vol. 112. New York: Springer, 2021. https://www.statlearning.com/ (17.2.2022.)	online	20
Bloomfield, Victor A. Using R for numerical analysis in science and engineering. Chapman and Hall/CRC, 2018.	2	20
Greenbaum, Anne, and Tim P. Chartier. Numerical methods: design, analysis, and computer implementation of algorithms. Princeton University Press, 2012.	2	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. M. Matetić, PhD / Assoc. prof. M. Brkić Bakarić, PhD	
Name of the course	**Data Mining**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

Automated data collection and advances in storage technology led to vast amounts of stored data. The goal of the course is to learn students how to apply different data mining methods and techniques in the task of knowledge discovery in different areas of application.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:
O1. Identify different data mining tasks and explain underlying data mining algorithms.
O2. Differentiate between different data types and data pre-processing techniques.
O3. Apply appropriate data mining methods, evaluate and interpret results.
O4. Critically explore and select data mining algorithms appropriate for a given task.
O5. Write a script or a program for conducting a data mining task on a given dataset.
O6. Select and apply advanced data mining tasks for solving business problems, interpret results, and present solutions.
O7. Explain the importance of linear algebra for data science and machine learning, floating point parameters, floating-point arithmetic, as well as its impact on accuracy.
O8. Analyse conditionality, complexity, and stability of numerical linear algebra for solving problems, e.g., the linear least squares problem, and the system of linear equations.

1.4. Course content

The course includes the following topics:

- Data mining definition and areas of application. Datatypes.
- Data pre-processing techniques. Balanced and imbalanced datasets.
- Feature selection methods.
- Classification, clustering, and association analysis techniques.
- Model training, model evaluation, and interpreting model results.
- Anomaly detection. Avoiding false discoveries.
- Using open-source tools for data mining tasks.
- A data mining project.

1.5. Manner of instruction

☒ lectures	☒ individual assignments
☒ seminars and workshops	☐ multimedia and network
☒ exercises	☐ laboratories
☒ distance learning	☐ mentorship
☐ fieldwork	☐ other

1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will conduct a data mining task, either individually or within a team.

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Attend classes and regularly follow course activities within the distance learning system.
- Take the final exam and achieve at least 50% of the overall number of points for this activity.
- Participate in continuous assessment activities such as homework, midterm exams, and project work.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[2]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Online quiz in which students demonstrate their understanding of the theoretical concepts (O1, O2, O7, O8), e.g. multiple choice tasks, cloze tasks.
- Continuous assessment in the form of practical work (exercises, midterm exams, and homework) includes conducting different data mining tasks (O3, O4, O5, O6), e.g. apply a machine learning method on a given dataset and evaluate results of the trained model.
- A final exam in the form of a project assignment on conducting a data mining task in a certain domain, writing a report, and presenting results (O3, O4, O5, O6), e.g. testing a hypothesis by cross-comparison of different data mining tasks and interpreting results.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, 2nd ed., Pearson, 2019.
2. Shmueli, Galit, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, and Kenneth C. Lichtendahl Jr. Data mining for business analytics: concepts, techniques, and applications in R. John Wiley & Sons, 2017.
3. James W. Demmel: Applied Numerical Linear Algebra, SIAM 1997.
4. Prepared learning materials available through the system for distance learning.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Data Mining: Practical Machine Learning Tools and Techniques, Ian Witten, Eibe Frank, Mark Hall, 4th ed.,Morgan Kaufmann, 2016.
2. Data Mining: The Textbook, Charu C. Aggarwal Hardcover, Springer, 2015
3. Gareth, James, Witten Daniela, Hastie Trevor, and Tibshirani Robert. An introduction to statistical learning: with applications in R. Spinger, 2021.
4. Bruce, Peter, Andrew Bruce, and Peter Gedeck. Practical statistics for data scientists: 50+ essential concepts using R and Python. O'Reilly Media, 2020.

[2] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Introduction to Data Mining, Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, Vipin Kumar, 2nd ed., Pearson, 2019.	2	20
Shmueli, Galit, Peter C. Bruce, Inbal Yahav, Nitin R. Patel, and Kenneth C. Lichtendahl Jr. Data mining for business analytics: concepts, techniques, and applications in R. John Wiley & Sons, 2017.	2	20
James W. Demmel: Applied Numerical Linear Algebra, SIAM 1997.	2	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Vedran Miletić	
Name of the course	**Big Data Infrastructure**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to acquire knowledge about the infrastructure in the background of applications and services of intelligent information systems that work with big data, and to acquire skills in the implementation and maintenance of such infrastructure in the cloud.

1.2. Course enrolment requirements

There are no enrolment requirements.

1.3. Expected learning outcomes

It is expected that after successfully fulfilling all the obligations stipulated in the program, the student will be able to:

O1. Choose distributed architectures for working with big data (eg lambda, kappa, delta, etc.) and appropriate tools for such architectures.

O2. Anticipate the needs of an intelligent information system for the infrastructure in the cloud with the connection to appropriate interfaces of data, information and knowledge repositories with associated metadata.

O3. Design a model of data management, coordination, message exchange, and interaction in an intelligent information system using appropriate methods and techniques (e.g. distributed databases, cache systems, message exchange systems, data streaming systems, etc.) and a corresponding distributed database model using appropriate languages for data modeling and taking into account the specifics of the system architecture.

O4. Recommend technologies for implementing the integration of data, information and knowledge from heterogeneous and distributed data systems that meet the requirements of the given problem.

O5. Choose an appropriate set of cloud technologies (eg monolithic and microservice architectures, containers, virtual machines, etc.) for the implementation of an intelligent information system.

O6. Develop intelligent cloud services based on data analytics and artificial intelligence, as well as related interfaces and appropriate documentation.

O7. Develop components of intelligent information systems and associated automated testing procedures using platforms, libraries, frameworks and cloud services as infrastructure.

O8. Implement an intelligent agent that solves the given problem using the default interfaces, services, applications, interaction mechanisms, and types of behavior suitable for the given problem, and an agent model of the system that will be used to simulate the system's behavior.

1.4. Course content

The content of the course consists of topics:

- Reliability, scalability, and sustainability of applications. Data models. Data storage and retrieval. Data encoding for storage and transmission.

- Data replication and partitioning. Transactions. Challenges of distributed systems: errors, unreliability, consistency guarantee, and consensus.
- Development and implementation of cloud-native applications. Cloud data operations. Portability between different clouds. The evolution of monolithic applications into microservices.
- Infrastructure and services for serial and streaming data processing. Intelligent information system and agent support services.
- Technological trends and the future of large-scale data processing systems.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	Teaching will be conducted by combining work in the classroom and independent work outside the classroom, with the use of an e-learning system.	

1.7. Student responsibilities

Responsibilities of students in the course are:

- Regularly attending classes, participating in all course activities, and monitoring notifications related to classes in the e-learning system.
- Take continuous knowledge assesments (theoretical and practical colloquiums) and successfully pass them.
- Create practical works (individual or team projects) on given topics and defend them.
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus.

1.8. Monitoring of student work[3]

Class attendance	2	Class participation		Seminar paper		Experimental work	1
Written exam	1	Oral exam	1	Essay		Research	
Project		Continuous assessment		Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- A written or online test in which the student will demonstrate the understanding and the ability to analyze and synthesize theoretical concepts of distributed systems, heterogeneous data systems, architectures for working with large-scale data, infrastructure of intelligent information systems, and cloud technologies (O1, O2, O4, O5).
- Experimental work with different architectures for working with big data and appropriate tools (e.g. Hadoop, Spark, Kafka, HBase, etc.) with the aim of collecting analytical metrics necessary for predicting infrastructure needs of an intelligent information system based on that architecture (O1, O2). In accordance with the provided infrastructure, the student will design a model of data management, coordination, message exchange, and interaction and also recommend technologies for the implementation of a heterogeneous and distributed data system (such as distributed relational and non-relational (NoSQL) databases, databases based on data streaming (e.g. Kafka), blockchain technologies and/or generalized databases, document-based databases, and media and

3 IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

object-oriented databases) (O3, O4).

- Practical work defended orally in which the student will choose an appropriate set of cloud technologies (such as AWS, Azure, Google Cloud, IBM Cloud, Scaleway, DigitalOcean, Watson, Wit.ai, Botpress, etc.) and use it for the development of an intelligent service (e.g. an intelligent agent or an intelligent information system component) based on data analytics and artificial intelligence and also associated interfaces (e.g. REST, WebSocket, TCP/UDP, ZMTP, AMQP, XMPP, etc.), with appropriate documentation (O5, O6, O8). As part of the development, they will also implement procedures for automated testing of the cloud service using appropriate technologies (e.g. unit testing, end-to-end testing, penetration testing, ethical hacking, etc.) (O7).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Takada, M. *Distributed systems: for fun and profit*. (Mixu, 2013). Available online: http://book.mixu.net/distsys/
2. Beyer, B., Jones, C., Petoff, J. & Murphy, N. R. *Site Reliability Engineering: How Google Runs Production Systems*. Available online: https://sre.google/sre-book/table-of-contents/
3. Kleppmann, M. *Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems*. (O'Reilly Media, 2017).
4. Scholl, B., Swanson, T. & Jausovec, P. *Cloud Native: Using Containers, Functions, and Data to Build Next-Generation Applications*. (O'Reilly Media, 2019).
5. Aspnes, J. *Notes on Theory of Distributed Systems*. (Aspnes, 2021). Available online: http://cs-www.cs.yale.edu/homes/aspnes/classes/465/notes.pdf
6. Content prepared by a learning system for learning.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Raman, A., Hoder, C., Bisson, S. & Branscombe, M. *Azure AI Services at Scale for Cloud, Mobile, and Edge: Building Intelligent Apps with Azure Cognitive Services and Machine Learning*. (O'Reilly Media, 2022).
2. Fregly, C. & Barth, A. *Data Science on AWS: Implementing End-to-End, Continuous AI and Machine Learning Pipelines*. (O'Reilly Media, 2021).
3. Winder, P. *Reinforcement Learning: Industrial Applications of Intelligent Agents*. (O'Reilly Media, 2020).
4. Adkins, H., Beyer, B., Blankinship, P., Oprea, A., Lewandowski, P. & Stubblefield, A. *Building Secure and Reliable Systems: Best Practices for Designing, Implementing, and Maintaining Systems*. (O'Reilly Media, 2020). Available online: https://sre.google/static/pdf/building_secure_and_reliable_systems.pdf
5. Reznik, P., Dobson, J. & Glenow, M. *Cloud Native Transformation: Practical Patterns for Innovation*. (O'Reilly Media, 2019).
6. Arundel, J. & Domingus, J. *Cloud Native DevOps with Kubernetes: Building, Deploying, and Scaling Modern Applications in the Cloud*. (O'Reilly Media, 2019).
7. Newman, S. *Monolith to Microservices: Evolutionary Patterns to Transform Your Monolith*. (O'Reilly Media, 2019).
8. Sridharan, C. *Distributed Systems Observability*. (O'Reilly Media, 2018).
9. Burns, B. *Designing Distributed Systems*. (O'Reilly Media, 2018).
10. Beyer, B., Murphy, N. R., Rensin, D., Kawahara, K. & Thorne, S. *The Site Reliability Workbook: Practical Ways to Implement SRE*. (O'Reilly Media, 2018). Available online: https://sre.google/workbook/table-of-contents/

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Distributed systems: for fun and profit	online	20
Site Reliability Engineering: How Google Runs Production Systems	online	20

Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems	1	20
Cloud Native: Using Containers, Functions, and Data to Build Next-Generation Applications	1	20
Notes on Theory of Distributed Systems	online	20
1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).		

General information		
Course instructor	Prof. Ana Meštrović, PhD	
Name of the course	**Programming for Artificial Intelligence**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The main objective of the course is to familiarize students with the programming for the field of artificial intelligence. The aim of the course is to learn how to apply numerical linear algebra, procedures for preparing data for processing, and declarative programming in the implementation of components of intelligent information systems.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Implement the chosen technique of numerical linear algebra to solve a given problem in the field of artificial intelligence.
O2. Choose an efficient numerical algorithm for a special class of matrices that is recognized in a given problem from the field of artificial intelligence with reference to the possible consequences of ill-conditioned matrices.
O3. Critically evaluate and select appropriate declarative programming techniques for solving the given problem in the field of artificial intelligence.
O4. Apply advanced programming techniques based on combining declarative programming and other programming paradigms to accessing data and preparing data for processing.
O5. Develop components for processing large amounts of data using processing methods appropriate to the given problem (e.g. parallel, distributed, network, multi-agent, etc.).
O6. Implement modules of intelligent information systems using programming languages for artificial intelligence and data analytics with the application of appropriate program modules.
O7. Develop a prototype of an intelligent information system for processing large data sets using programming languages and libraries for artificial intelligence and data analytics.
O8. Develop automated procedures for testing individual components of an intelligent information system using techniques appropriate to the given problem.

1.4. Course content

The course includes the following topics:

- Application of numerical linear algebra to solve a given problem in the field of multivariate statistics, machine learning and artificial intelligence. Implement the given method of numerical linear algebra in a suitable programming language. Numerical algorithms for a numerical algorithm for a special class of matrices (symmetric, Hermitian, normal, unitary, positive definite).
- Overview of the consequences of ill-conditioned matrices on the accuracy and speed of convergence of iterative algorithms of numerical linear algebra.

- Advanced programming techniques for accessing data and preparing data for processing. Data handling: data collection, data models, common data set problems, data transformation, data cleansing. Overview of approaches in processing large amounts of data: parallel, distributed, network, multi-agent, etc.
- Domain-specific languages (syntax, semantics, pragmatics) and metaprogramming techniques (eg BNF grammars, finite automata, regular languages, etc.).
- Application of appropriate program modules for artificial intelligence and data analytics. Automated component testing procedures.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will work independently or as a team on a project assignment.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes and participate in all course activities and follow notifications related to classes in the e-learning system.
- Take the final exam and score at least 50% on it.
- Students' obligations include homework, colloquiums, seminars and project assignments.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[4]

Class attendance	2	Class participation		Seminar paper	0.5	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1.5	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written examination related to numerical linear algebra. Example question: Comment on the consequences of matrix ill-conditioning on the accuracy and speed of convergence of iterative algorithms of numerical linear algebra. First midterm exam (O1, O2).
- Written exam related to the preparation and processing of data. Example question: List methods and techniques for data preparation. Second midterm exam (O3, O4, O5).
- Project task - example: Implement modules of intelligent information systems using programming languages for artificial intelligence and data analytics with the application of appropriate program modules for the development of systems for analyzing data collected from social networks (O3, O4, O5, O6).

[4] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- Final exam: written test of knowledge related to the declarative programming paradigm. Example question: Explain the possibility of implementing declarative programming for the development of an intelligent information system (O3, O7, O8).
- Practical part of the final exam - example: Develop a prototype of an intelligent information system for processing datasets about interactions on social networks using programming languages and libraries for artificial intelligence and data analytics and test the system (O7, O8).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2010.).
2. Jacob T. Vanderplas, Jake VanderPlas, Python Data Science Handbook, O'Reilly Media (2016.).
3. Aggarwal, Charu C., Aggarwal, and Lagerstrom-Fife. Linear algebra and optimization for machine
4. learning. Springer International Publishing, (2020.).
5. Content prepared for learning and published in Merlin

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Charniak, Eugene, Christopher K. Riesbeck, Drew V. McDermott, and James R. Meehan. Artificial intelligence programming. Psychology Press, 2014.
2. Subhash Sharma (1995.), Applied multivariate techniques, John Wiley & Sons
3. Mark Hall, Ian W. Witten, Eibe Frank, Mark A. Hall, Christopher J. Pall (2017.), Data Mining, Practical Machine Learning Tools and Techniques, Morgan Kaufmann

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2010.).	4	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Danijela Jakšić, PhD	
Name of the course	**Electronic Commerce and Digital Innovations**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire basic and extended knowledge in the field of electronic commerce and digital innovations. This knowledge, among other things, includes market analysis in the context of the use of information and communication technology (ICT) products, evaluation of ICT innovation management processes in business, innovation management and creation of a business idea and a startup plan, and creation of system design proposals for electronic commerce.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Analyse the market in the context of the use of information and communication technology products, with the aim of developing a business idea, selecting or creating application software and managing digital innovations.
O2. Evaluate the processes of planning, development and management of ICT innovations in business.
O3. Create a business plan for innovation management using the appropriate template and canvases for the elaboration of the business idea, and according to the rules of the profession and examples of good practice.
O4. Distinguish basic concepts, structures, models, documents and principles of electronic commerce and payments.
O5. Evaluate the features of multi-platform and native mobile applications for electronic commerce, as well as different paradigms of desktop, web and mobile application development.
O6. Critically review chosen professional IT standards, the implementation of the ethical code of the IT profession in a business organization, and the problems of personal data protection in the context of modern information and communication technologies.
O7. Create a design proposal for an electronic commerce system or business application based on the analysis and testing of existing systems in various domains of application, and according to the rules of the profession and methods of good development practice.

1.4. Course content

The course includes the following topics:

- Analysis of ICT trends and the impact of ICT on the market and users. Impacts of ICT on education, work organization and economy: techno-economy, network enterprise, e-learning, flexibility. ICT and network economy, globalization and its effects. Factors of technological development: social support and personal preference for technology, entrepreneurship. Privacy, surveillance of people and events, civil society. Virtual reality and virtual communities. ICT and the culture of cooperation and giving: Wikipedia, Linux. Open source software, data volume, data availability, data processing and

analysis. Social networking systems: Facebook, YouTube, Twitter, and others - mass communication, manipulation, self-communication and its effects. Technological progress and the main features of modern life. ICT and society: problems, challenges and perspectives.

- ICT innovations. Innovation life cycle. Barriers to innovation. Types of innovation (product, service, business process, business model innovation, ...). Innovation management. Roles of participant groups in innovation management processes. Methods for creating a positive innovation climate necessary for the introduction and improvement of innovations in organizations. Creation and evaluation of a business idea. Intellectual property. Patent. Copyright. Basics of the Lean Startup approach. Lean Startup Canvas. Comparison of Lean Startup with Design Thinking and Business Model approaches and other trends in business planning. Startup and entrepreneurship. Sources of funding for startups. Business incubators. Crowdfunding. Financial plan. A startup plan for your own business idea and product. Startup pitch.
- Basic concepts and principles of electronic commerce. Structure of e-commerce. E-market and online communities. Business models of e-commerce (B2B, B2C, C2C, C2G, G2C, ...). Mobile business. Electronic commerce standards. Electronic documents. Data and process modelling for electronic commerce. Electronic payment. Security and privacy in electronic commerce and payment. Application of electronic commerce (E-shop. E-administration. E-entertainment. E-learning. E-finance. E-banking. E-health. E-transport. E-tourism. E-reservations., ...). Legal, ethical and social aspects of electronic commerce. Designing systems for electronic commerce.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, practical work, project activities, seminar paper) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[5]

Class attendance	2	Class participation	0.5	Seminar paper	1	Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	1.5

[5] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assesment of the set of learning outcomes is done through class activities and/or forum discussions, writing a seminar paper, doing the practical work (project assignment) and taking the final exam:

• During class activities and/or forum discussion, student analyses the market and gives a critical review in the context of the use of information and communication technology products in various domains of application (O1), and makes a critical judgment about the characteristics of different types of licenses in the field of software development and application, the application of appropriate professional IT standards, the implementation of the elements of the code of ethics of the IT profession in the business organization and the problems of personal data protection (O6). For example, analyse market coverage of open source software in the domains of retail, education and healthcare, or provide a critical review of the ethical context of privacy settings and standards on selected social networks and media.

• Seminar paper (innovation, ICT product and startup plan) includes designing an innovative ICT product, shaping a business idea and creating a business (startup) plan (O2, O3). For example, come up with an idea (innovation) and create a business plan for the ICT project "Mobile application Presence".

• Practical (project) work includes making proposals for the design and prototype development of ICT product for electronic commerce, based on the analysis and testing of existing similar systems in various domains of application. (O7). For example, Create a project on the topic "MyFin e-banking".

• In the written final exam, student demonstrates an understanding of the concepts, procedures, methods, principles, platforms and tools of electronic business (O4, O5). For example, enumerate and describe business models for e-commerce, or distinguish basic methods for electronic payment.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Lindgren, S. (2017). Digital media & society. SAGE Publications Ltd.
2. Ede, A. (2019). Technology and Society: A World History. Cambridge University Press.
3. Bhargava, R., Herman, W. (2020). The Startup Playbook: Founder-to-Founder Advice from Two Startup Veterans. John Wiley & Sons.
4. Schneider, G. (2016). Electronic Commerce. Cengage Learning.
5. Sherif, M. H. (2016). Protocols for Secure Electronic Commerce. CRC Press
6. Prepared learning materials available through the system for distance learning

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Aspray, W., Tozzi, C. & Zittrain, J. (2017). For Fun and Profit: A History of the Free and Open Source Software Revolution (History of Computing). The MIT Press.
2. Hartzog, W. (2018). Privacy's Blueprint. Harvard University Press.
3. Diamandis, P.H. & Kotler, S. (2020). The Future Is Faster Than You Think: How Converging Technologies Are Transforming Business, Industries, and Our Lives. Simon & Schuster.
4. Hoffman, S.S. (2021). Surviving a Startup: Practical Strategies for Starting a Business, Overcoming Obstacles, and Coming Out on Top. HarperCollins Leadership.
5. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business.
6. Scobey, P., Lingras, P. (2018). Web Programming and Internet Technologies: An E-Commerce Approach. Jones & Bartlett Learning.
7. Wei, J. (2015). Mobile Electronic Commerce: Foundations, Development, and Applications. CRC Press.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Lindgren, S. (2017). Digital media & society. SAGE Publications Ltd.	1	20
Ede, A. (2019). Technology and Society: A World History. Cambridge University Press.	1	20

Schneider, G. (2016). Electronic Commerce. Cengage Learning.	1	20
Bhargava, R., Herman, W. (2020). The Startup Playbook: Founder-to-Founder Advice from Two Startup Veterans. John Wiley & Sons.	1	20
1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).		

General information		
Course instructor	Full Prof. Patrizia Poščić, PhD	
Name of the course	**Non-relational and Distributed Databases**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire knowledge in the field of non-relational and distributed databases. This knowledge, among other things, includes the conceptual and logical design of non-relational and distributed databases, their physical implementation in appropriate technologies, and the formulation of queries over semi-structured data.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Distinguish basic concepts, methods and processes, as well as types of non-relational databases.
O2. Distinguish basic concepts, communication models, protocols and types of distributed databases.
O3. Create a conceptual and logical model of a non-relational or distributed database using appropriate modelling tools, based on the specific problem situation and domain.
O4. Recommend technologies for the implementation of non-relational or distributed data systems that meet the requirements and specifics of the business problem.
O5. Design the organization of large sets of data, information and knowledge, as well as the logical and physical model of databases for large sets of data, using data infrastructures appropriate to the set business problem.
O6. Implement a non-relational or distributed database based on a conceptual, logical and/or physical model, in an appropriate language for working with databases and taking into account the specifics of the business problem, data and system architecture.
O7. Create queries over semi-structured data in selected query languages for various database technologies.

1.4. Course content

• Basic concepts, techniques and processes of non-relational databases. Types of non-relational databases.
• Basic concepts, communication models, protocols, types and architectures of distributed databases.
• Conceptual and logical model of non-relational and distributed database.
• Systems for managing non-relational and distributed databases.
• Query languages for non-relational and distributed databases.
• Organization of large sets of data, information and knowledge. A logical and physical database model for large data sets.
• Implementation of non-relational and distributed database.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☐ seminars and workshops	☐ multimedia and network

	☒ exercises ☒ distance learning ☐ fieldwork	☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, practical work, project activities, seminar paper) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[6]

Class attendance	2	Class participation		Seminar paper	1.5	Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	1.5
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assesment of the set of learning outcomes is done through class activities and/or forum discussions, writing a seminar paper, doing the practical work (project assignment) and taking the final exam:

• Seminar paper includes research on a given topic and in a given format (O4, O5). For example, create a research seminar paper on the topic "Comparison of selected technologies for the implementation of graph non-relational database".

• Practical work includes the creation of a conceptual and logical model of a non-relational or distributed database, its physical implementation in appropriate technologies and tools, and the formulation and execution of database queries O3, O6, O7). For example, create a practical work on the topic "Document non-relational database for Ebay in MongoDB".

• In the written final exam, student demonstrates an understanding of the concepts, procedures, methods, principles and technologies of non-relational and distributed databases (O1, O2). For example, enumerate and describe the basic types of non-relational databases, or describe the basic communication models of distributed databases.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Meier, A., Kaufmann, M. (2019). SQL & NoSQL Databases: Models, Languages, Consistency Options and Architectures for Big Data Management. Springer.

[6] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

2. Perkins, L., Redmond, E., Wilson, J. (2018). Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement. Pragmatic Bookshelf.
3. Tamer Özsu, M., Valduriez, P. (2019). Principles of Distributed Database Systems. Springer.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Sullivan, D. (2015). NoSQL for Mere Mortals. Addison-Wesley.
2. Pivert, O. (2018). NoSQL data models: trends and challenges. Wiley.
3. Hills, T. (2016). NoSQL and SQL Data Modeling: Bringing Together Data, Semantics, and Software. Technics Publications.
4. Petrov, A. (2019). Database Internals: A Deep Dive into How Distributed Data Systems Work. O'Reilly Media.
5. Appropriate software manuals

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Meier, A., Kaufmann, M. (2019). SQL & NoSQL Databases: Models, Languages, Consistency Options and Architectures for Big Data Management. Springer.	1	20
Perkins, L., Redmond, E., Wilson, J. (2018). Seven Databases in Seven Weeks: A Guide to Modern Databases and the NoSQL Movement. Pragmatic Bookshelf.	1	20
Tamer Özsu, M., Valduriez, P. (2019). Principles of Distributed Database Systems. Springer.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Asooc. Prof. Božidar Kovačić, PhD	
Name of the course	**Information Security and Blockchain Technologies**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to acquire basic knowledge in the field of information security and privacy development, to analyse risks and threats to information systems and to act in incident situations, and to acquire basic knowledge for the development of security solutions based on blockchain technology.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:
O1. Create a security policy proposal for a given service or product.
O2. Analyse the vulnerability of the information security and privacy system and create a proposal for preventive measures to reduce vulnerability.
O3. Identify the sources, forms and intensity of risk and choose the best practice (methodology) and norms in risk analysis.
O4. Design procedures for reporting and monitoring incidents and recording the consequences of incidents.
O5. Create a proposal for measures and techniques to mitigate the consequences of an incident situation.
O6. Analyse security solutions based on blockchain technology.
O7. Create security requirements when developing a security solution based on blockchain technology

1.4. Course content

The course includes the following topics:

- Security management of information systems, security policy, security level measurement, standards.
- Risks and threats to information systems. Security threats and the probability of their occurrence. Vulnerability of information systems.
- Security risk management. Methods for risk assessment. Quantitative and qualitative analysis and risk assessment.
- Security incidents of information systems. Measures and techniques for mitigating the consequences of an incident situation.
- Security of communication channels. Security threats. Security channels.
- Security solutions based on blockchain technology. Security of communication using blockchain technology.
- Security requirements when developing security solutions based on Blockchain technology.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops	☒ individual assignments ☐ multimedia and network

	☒ exercises ☒ distance learning ☐ fieldwork	☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes, actively participate in all activities on the course and follow notifications related to classes in the e-learning system.
- Take part in individual or team activities during class (class activities and/or forum discussions, homework and practical work) and must achieve a number of points greater than or equal to the set passing threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[7]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	1.5	Oral exam		Essay		Research	
Project		Continuous assessment	1	Report		Practical work	1.5
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The set of learning outcomes is checked through class activities and/or forum discussions, homework, practical work and writing the final exam, all while working on a computer:

- in class activities, the student analyses the methods and procedures of building an information security and privacy system. For example, for a given organizational system, a proposal of methods and procedures for building an information security and privacy system is created (O1, O3).
- in the written exam, the student demonstrates an understanding of security policy concepts, and defines the elements of security policy for a given service or product: security measures for personnel, communication security, physical security, operational security (O1, O2).
- in the framework of practical work for a hypothetical security incident, students identify procedures for reporting and monitoring incidents and recording the consequences of incidents. Based on the proposed measures, the student creates a proposal for measures and techniques to mitigate the consequences of the incident situation (O4, O5).
- in class activities, the student analyses the application of blockchain technology on the basis of applied security solutions and defines the requirements of security solutions for the given service (O6, O7).
- in the written final exam, the student demonstrates understanding of concepts, methods, techniques and approaches to security and privacy management (O1, O2, O3) and understanding of security requirements when developing security solutions based on Blockchain technology (O6, O7).

[7] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Harold F. Tipton, Micki Krause, "Information Security Management", 6th Edition, Taylor & Francis Group, 2007.
2. Douglas J. Landoll, "Information Security Policies, Procedures, and Standards: A Practitioner's Reference 1st Edition", RC Press, Taylor & Francis Group, 2016.
3. Lorne Lantz, Daniel Cawrey, " Mastering Blockchain: Unlocking the Power of Cryptocurrencies, Smart Contracts, and Decentralized Applications", O'Reilly, 2021.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Michael E. Whitman, Herbert J. Mattord, "Management of Information Security", Cengage Learning, 2018.
2. Darril Gibson, Andy Igonor, "Managing Risk in Information Systems (Information Systems Security & Assurance) 3rd Edition", O'Reilly, 2022.
3. Jeff Bollinge, Brandon Enright, Matthew Valites, "Crafting the InfoSec Playbook: Security Monitoring and Incident Response Master Plan", O'Reilly, 2015.
4. Mastering Blockchain: Unlocking the Power of Cryptocurrencies, Smart Contracts, and Decentralized Applications, O'Reilly, 2020.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Michael E. Whitman, Herbert J. Mattord, "Management of Information Security", Cengage Learning, 2018.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Martina Holenko Dlab, PhD	
Name of the course	**Quantitative Methods for Business Decision Making**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire knowledge of the procedures for formalizing business problems and applying quantitative methods to identify and analyse their solutions for the purpose of making decisions in a business environment.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Explain the basic concepts of binary relations on discrete sets, elementary number theory, graph theory, business decision theory, and simulation.
O2. Compare various quantitative methods for making business decisions based on knowledge of their properties and characteristic examples of their application.
O3. Analyse, construct, and apply standard forms of mathematical proofs in solving problems.
O4. Formulate a mathematical model for a real business problem described in words.
O5. Evaluate the mathematical model and problem solution based on sensitivity analysis.
O6. Solve real-world problems by applying appropriate quantitative methods and specialized program support.
O7. Analyse and interpret the results of applying quantitative methods in the context of business problems with the goal of supporting business decision making.

1.4. Course content

The course includes the following topics:

- Formulation of a conceptual model of a business problem using various techniques and methods.
- Binary relations on discrete sets, elementary number theory, and mathematical proofs in modelling and solving business problems.
- Solving problems using the congruence calculus.
- Graph theory. Classification and representation of graphs. Theorems and algorithms of graph theory.
- Modelling scheduling problems using directed graphs (networks).
- Concepts of normative, prescriptive and descriptive decision theory.
- Methods for multi-attribute and multi-criteria decision-making.
- Modelling of multi-attribute and multi-criteria decision problems.
- Simulation modelling for solving business problems.
- Model validation and sensitivity analysis.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☐ seminars and workshops	☐ multimedia and network
	☒ exercises	☒ laboratories

	☒ distance learning ☐ fieldwork	☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in practical problem-solving tasks during lectures and auditory and/or laboratory exercises.
- Complete a project assignment on a given topic, individually or in a team, and document its development.
- Participate in continuous assessment activities and successfully complete them.
- Take the final exam and achieve at least 50% of the points.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[8]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project	0.5	Continuous assessment	1	Report		Practical work	1.5
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Test (theoretical preliminary exam, final exam) in the form of an online test in which the student is expected to demonstrate knowledge of basic concepts related to quantitative methods for business decision making by answering questions (e.g., multiple-choice questions, matching tasks, essay questions), identifying the given problem and its characteristics, and indicating which methods would be appropriate to solve the problem (O1, O2).
Practical tasks and practical exams in which the student is expected to model a given problem described in the text, evaluate the model, and determine the solution to the problem using the appropriate method and with program support (O3, O4, O5, O6).
A project task (individually or in a team) in which the student is to solve practical problems, interpret and analyse the results obtained, and use the program to create a quantitative basis for the decision-making process (O7).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Hillier F., Lieberman G. (2010). Introduction to Operations Research. California, Oakland: Holden-Day Inc.
2. Babić Z. (2017). Modeli i metode poslovnog odlučivanja. Split: Ekonomski fakultet.
3. Prepared learning materials available through the system for distance learning.

[8] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Murthy, G. S. R. (2015). Applications of Operations Research and Management Science, Springer.
2. Winston, W. L., Goldberg, J. B. Operations research: applications and algorithms. Belmont: Thomson Brooks/Cole, 2004.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. Ana Meštrović, PhD	
Name of the course	**Complex Networks Analsis**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The main objective of the course is to familiarize students with the programming for the field of artificial intelligence. The aim of the course is to learn how to apply numerical linear algebra, procedures for preparing data for processing, and declarative programming in the implementation of components of intelligent information systems.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Explain the fundamental terminology and algorithms in the area of complex network analysis.

O2. Critically analyze methods for static analysis of complex networks (global, central and local level) and their applicability to different forms of data from different domains.

O3. Recommend an appropriate set of technologies and tools for data collection, network modeling, and system development for network analysis within an intelligent system.

O4. Develop and implement a system that uses complex network analysis methods to analyze network data from a given problem domain (eg complex co-authorship networks, protein interaction networks, social networks, transport networks, etc.).

O5. Implement a model for dynamic network analysis (e.g. predicting the spread of information or predicting future links in the network)

O6. Carry out simulation and analysis of dynamic network analysis results.

O7. Critically analyze the possibility of applying more complex structures such as a multiplex network or a multilayer network for the analysis of complex data that can be formed as a multilayer network.

O8. Implement a suitable machine learning model for a given task in the field of classification of complex networks (e.g. automatic recognition of the behavior of treated and untreated fruit flies based on the network of their social interactions).

1.4. Course content

The course includes the following topics:

- Introduction to the analysis of complex networks.
- Historical development of the area.
- Overview of various possible applications of methods and techniques in the field of complex network analysis.
- Overview of local and global measures.
- Algorithms for community identification.

- Algorithms for predicting future links in the network.
- Network visualization.
- Analysis of network dynamics (cascades, network changes over time, network growth).
- An overview of the properties of various prominent network models (small-world network models, scale-free networks,
- etc.).
- Modeling and analysis of more complex structures: multiplex, multilayer.
- Application of machine learning algorithms in network classification tasks.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will work independently or as a team on a project assignment.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes and participate in all course activities and follow notifications related to classes in the e-learning system.
- Take the final exam and score at least 50% on it.
- Students' obligations include homework, colloquiums, seminars and project assignments.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[9]

Class attendance	2	Class participation		Seminar paper	0.5	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1.5	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written or online knowledge test in which the student demonstrates understanding of the theory of complex network analysis (O1, O2), for example by means of multiple choice questions, completion questions and/or essay questions, the student should explain what a small-world network is, a network without scales, preferential connection, how "hubs" are formed, etc.
- A practical project task in which the student has to choose an appropriate network/graph model and shape the data, construct a network for a given concrete problem and analyze a given network at the local, central and global level (O3, O4, O5, O6), for example, make an analysis for the network of social interactions of wine flies at the local, central and global levels.
- A practical task (practical colloquium) in which the student applies procedures for predicting future links in the network (using node similarity measures implemented in e.g. Python) (O5, O6), for

[9] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

example to evaluate algorithms for predicting future links implemented in Python (Adamic/ Adar, Jaccard Index, Preferential attachment, ...) on a given network.

- A practical project task in which the student applies skills and knowledge from the field of complex network analysis when solving problem tasks according to predetermined instructions and evaluation criteria (O7, O8).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Newman, M. (2018). Networks. Oxford university press.
2. Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2010.).
3. Russell, M. A. (2013). Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Google+, GitHub, and More. " O'Reilly Media, Inc.".
4. Content prepared for learning and published in Merlin

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Scott, J. (2017). Social network analysis. Sage.
2. Liu, Zhiyuan, and Jie Zhou. "Introduction to graph neural networks." Synthesis Lectures on Artificial Intelligence and Machine Learning 14, no. 2 (2020): 1-127.
3. Wasserman, S., & Faust, K. (1994). Social network analysis: Methods and applications (Vol. 8). Cambridge university press.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2010.).	4	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Nataša Hoić-Božić	
Name of the course	**E-learning for Education and Business**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is the acquisition of basic knowledge and the development of skills necessary for analysing, planning, and creating e-learning in educational and professional institutions. Students will be familiar with the possibilities of applying modern digital technologies for e-learning and the possibilities of digital transformation of e-learning. They will actively use the e-learning system and be able to plan to acquire additional knowledge, skills and abilities through lifelong e-learning.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Discuss the concepts and theories in the field of e-learning, their connection and relevance to solving the complex current and future challenges of the digital transformation of e-learning.

O2. Identify the possibilities of modern digital technologies for e-learning (LMS, digital tools, MOOCs, new technologies – AR, VR, digital games) and recommend suitable technologies for e-learning in the organization and educational institution.

O3. Design innovative e-learning approaches and models for successful application in the organization and educational institution.

O4. Develop a plan to improve e-learning in the organization and educational institution by applying modern approaches and models of e-learning as well as technological innovations.

O5. Analyse, identify the need, plan activities, resources, methods, techniques, and tools as well as design, implement and evaluate e-learning models in an organization or educational institution based on the instructional design standards.

1.4. Course content

- E-learning, blended learning, and distance education: definition, advantages, disadvantages, forms, technology, work methods. Online courses. Evaluation in e-learning. E-tivities.
- Application of modern digital technologies for e-learning (LMS, digital tools, MOOC, new technologies – AR, VR, digital games).
- The role of computer experts in the digital transformation of e-learning in the organization and educational institution.
- Instructional design models for planning, implementing, and evaluating e-learning in an organization or educational institution.
- Application of the learning system (LMS), digital tools and other technologies for the preparation of e-learning in the organization and educational institution.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines classroom work, individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Participate in continuous assessment activities (theoretical preliminary exams) and successfully complete them.
- Complete an individual or group assignment (seminar paper) on a given topic and present it to the course instructor and other students.
- Prepare a project, as the final exam. This activity requires the student to achieve at least 50% of the overall number of points for this activity.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[10]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written or online test (theoretical preliminary exam) in which students demonstrate their understanding of the basic theoretical concepts related to e-learning and the process of digital transformation of e-learning (O1), and which may include recall type-tasks, multiple choice tasks, matching tasks, essay questions, and extended response items.
- Forum discussion in which students discuss on the topics related to the e-learning e.g. about advantages and disadvantages of particular digital technologies for e-learning with some recommendations how to use it successfully (O2)
- Group assignment (using wiki or similar tool) in which students collaboratively analyse e-learning approaches and models and propose solutions for successful application in the organization and educational institution (O3, O4). Students will receive in advance instructions for creating and criteria for evaluating the seminar.
- Group or individual practical project assignment in the form of an e-course in a suitable learning management system (e.g. Moodle) on a selected topic in the field of informatics prepared by students following the instructional design model. Based on previously prepared analysis and design (project

[10] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

documentation), they create and evaluate the e-course. Students will receive in advance instructions for creating and criteria for evaluating the project (O5).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Hoić-Božić, N., Holenko Dlab, M. (2021). „Uvod u e-učenje: obrazovni izazovi digitalnog doba“, Sveučilište u Rijeci, Odjel za informatiku, Rijeka.
2. Prepared learning materials available through the system for distance learning

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Bates, A. W. (2019). Teaching in a Digital Age – Second Edition. Vancouver, B.C., Tony Bates Associates Ltd. Dostupno online: https://pressbooks.bccampus.ca/teachinginadigitalagev2/ (9.5.2020.)
2. Ćukušić, M., Jadrić, M. (2021). „E-učenje: koncept i primjena“, Školska knjiga, Zagreb, 2012.
3. Horton, W. (2012). E-Learning by Design. New York: John Wiley & Sons, Inc.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Hoić-Božić, N., Holenko Dlab, M. (2021). „Uvod u e-učenje: obrazovni izazovi digitalnog doba“, Sveučilište u Rijeci, Odjel za informatiku, Rijeka. Available online: https://repository.inf.uniri.hr/islandora/object/infri:768 (17.2.2022.)	online	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assoc. Prof. Božidar Kovačić, PhD	
Name of the course	**Distributed Processing in Heterogeneous Systems**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is the acquisition of basic knowledge in the field of distributed systems and the acquisition of the basic concepts of distributed operating systems: communication and synchronization, data management, security and protection, as well as familiarization of students with methods of parallel programming on heterogeneous systems and acquisition of knowledge for the application of methods of parallel programming on heterogeneous systems in solving specific problems.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Determine the differences in the performance of distributed operating systems in relation to operating systems for personal computers and network operating systems.
O2. Explain the execution of remote procedure calls, the use of objects and messages for communication purposes in distributed systems.
O3. Analyze the differences in the operation of synchronization mechanisms for: clock synchronization, selection algorithms, mutual exclusion, distributed transactions.
O4. Analyze reliability protocols and error recovery mechanisms of distributed systems.
O5. Propose security techniques and mechanisms for a given distributed system.
O6. Determine the relationship of multicore to parallel and distributed programming techniques, especially considering the differences in the way CPU-type devices and GPU-type devices work.
O7. Create a programming solution for a real problem using parallel and distributed programming techniques.

1.4. Course content

The course includes the following topics:

- Distributed systems: definition, software and hardware concepts. Client-server models.
- Communication in distributed systems: remote procedure call, objects, message communication.
- Processes: client and server execution, code migration, software agents.
- Parallelism in data processing. Basic program structures, data types, operators and functions.
- Hardware architecture of heterogeneous systems. Platforms, devices and contexts. Data transfer between the memory of different devices.
- Events, notifications and synchronization. Code performance analysis and code debugging.
- Naming: naming entities, locating mobile entities.
- Synchronization: clock synchronization, selection algorithms, mutual exclusion, distributed transactions.
- Consistency and replicas: distributed protocols, consistency protocols.

- Repair in case of errors: reliability of client-server communication, reliability of group communication, recovery.
- Security in distributed systems

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes, actively participate in all activities on the course and follow notifications related to classes in the e-learning system.
- Access individual or team assessment activities during the course of the course (class activities and/or forum discussions, homework and practical work) and must achieve a number of points greater than or equal to the set passing threshold (if it exists).
- Take the final exam and obtain at least 50% of the grade points.

The detailed way of working out the scoring of the course and the pass thresholds for individual evaluation activities will be specified in the detailed implementation curriculum of the course.

1.8. Monitoring of student work[11]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project		Continuous assessment	1	Report		Practical work	2
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The set of learning outcomes is checked through class activities and/or forum discussions, homework, practical work and writing the final exam, all while working on a computer:

- In the written exam, the student explains the synchronization mechanisms of distributed systems and message communication in distributed systems (remote procedure call, RMI) (O1, O2).
- In the written exam, the student explains the implementation of reliability and recovery of distributed systems in the event of an error and the security mechanisms used in distributed systems (O4, O5).
- The student prepares a group or individual project task in which, according to predetermined instructions and evaluation criteria, he analyzes certain concepts of distributed processing in heterogeneous systems, for example those related to memory management, data processing, input-output operations using appropriate technologies (e.g. MPI, CUDA, SYCL) (O2, O3, O6, O7, O8).

1.10. Mandatory literature (at the time of submission of study programme proposal)

[11] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1. Tanenbaum A. & Steen, M. V. Distributed Systems: Principles and Paradigms (2nd Edition). (Prentice Hall, 2006).
2. Harold F. Tipton, Micki Krause, "Information Security Management", 6th Edition, Taylor & Francis Group, 2007.
3. David B. Kirk, Wen-mei W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach (Applications of GPU Computing Series), 2nd Edition, Morgan Kaufmann, 2012.
4. Frank Nielsen, Introduction to HPC with MPI for Data Science, 1st Edition, (Springer 2016).
5. Skripte, prezentacije i ostali materijali za učenje dostupni u e-kolegiju

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Coulouris G., Dollimore J. & Tim Kindberg T. Distributed Systems: Concepts and Design (5th Edition). (Addison-Wesley, 2011).
2. Silberschatz A. & Galvin P. B. Operating System Concepts. (Addison Wesley, 1989).
3. MPI for Python documentation. Dostupno na: mpi4py.readthedocs.io
4. Open MPI documentation: www.open-mpi.org/doc/
5. MPI Documents. Dostupno na: www.mpi-forum.org/docs/
6. Rob Farber, CUDA Application Design and Development, 1st Edition, Morgan Kaufmann, 2011.
7. Wen-mei W. Hwu, GPU Computing Gems Jade Edition (Applications of GPU Computing Series),1st Edition, Morgan Kaufmann, 2011.
8. Wen-mei W. Hwu, GPU Computing Gems Emerald Edition (Applications of GPU Computing Series),1st Edition, Morgan Kaufamann, 2011.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
David B. Kirk, Wen-mei W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach (Applications of GPU Computing Series), 2nd Edition, Morgan Kaufmann, 2012. https://safari.ethz.ch/architecture/fall2019/lib/exe/fetch.php?media=2013_programming_massively_parallel_processors_a_hands-on_approach_2nd.pdf *(17.2.2022.)*	online	20
Tanenbaum A. & Steen, M. V. Distributed Systems: Principles and Paradigms	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Associate Prof. Marina Ivašić-Kos, PhD	
Name of the course	**Machine and Deep Learning**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	2+2+0

1. COURSE DESCRIPTION

1.1. Course objectives

The goal of the course is to present the application of artificial intelligence and the basic procedures of machine and deep learning with an overview of the possibilities of their application. The course includes two basic approaches to machine learning: supervised learning (classification and regression) and unsupervised learning (clustering and dimensionality reduction), as well as key components and learning methods of deep models.

1.2. Course enrolment requirements

There are no requirements for course enrollment.

1.3. Expected learning outcomes

It is expected that after successfully fulfilling the obligations in the course, the student will be able to:

O1. Compare the advantages and disadvantages of basic machine learning algorithms, especially those related to classification, clustering and linear regression

O2. Collect and preprocess data for machine/deep learning, extract features and select the most suitable set of features for data representation

O3. Analyze and apply appropriate machine learning methods when solving specific problems of classification, grouping and linear regression

O4. Analyze and select deep learning methods that are suitable for supervised, semi-supervised and unsupervised learning

O5. Evaluate the performance and interpret the results of the model and, based on that, choose the best machine or deep learning model for the given problem

O6. Design and apply a deep learning model to a self-defined machine learning problem

O7. Discuss the areas of application of artificial intelligence and explain related problems such as explainability, interpretability, transparency, protection of personal data and ethical challenges in various areas of application of artificial intelligence.

1.4. Course content

The course includes the following topics:

- Intelligent systems, definitions, history, application.
- Introduction to the field of machine learning, overview of terms and definitions. Examples of machine learning tasks.
- Unsupervised learning and finding frequent patterns. Grouping algorithm: k means.
- Supervised learning. Classification and regression problems.
- Methods for supervised machine learning: linear regression, k nearest neighbour, trees and decision rules, support vector machines.
- Evaluation methods. Evaluation and selection of a predictive model.

- Data sets. Working with data and data preprocessing (incomplete, non-existent, structured and unstructured).
- Data representation: selection, ranking and extraction of features. Normalization.
- Artificial neural networks. Perceptron. A multi-layer perceptron.
- Architecture of multilayer neural network (neurons, input and output layers, hidden layers), activation functions and learning principles. Regularization of parameters, overfitting and generalization.
- Introduction to deep learning. Overview of terms and definitions.
- Basic architecture of deep neural network, network hyper parameters, loss function, optimization algorithms.
- Typical architectures of deep neural networks (CNN, RNN, ...).
- Convolutional neural networks and application to image data.
- The problem of explainability, interpretability, transparency of the model. Legal frameworks and ethical challenges. Protection of personal data.
- Using environments and services to define deep neural network architecture and develop deep learning applications (e.g. TensorFlow, Keras and Google Colab).

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course combines independent work when adopting concepts and team and project work when solving specific problems.	

1.1. Student responsibilities

The student is expected to:

- regular attendance and participation in classes, and monitoring notifications related to classes in the e-learning system,
- access continuous knowledge checks (theoretical and practical colloquiums);
- design and create a practical project of machine or deep learning for the selected problem and data, write a report and take the final exam. In the final exam student will present the project and describe the experiment, evaluate and interpret the obtained results and explain the selection of the best model (at least 50% points must be achieved in the final exam)

Detailed class activities and scoring will be specified in course syllabus.

1.2. Monitoring of student work[12]

Class attendance	2	Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	1
Project	1.5	Continuous assessment		Report		Practical work	
Portfolio						Report and presentation of results	0.5

1.3. Assessment of learning outcomes in class and at the final exam (procedure and examples)

• Practical test (colloquium on the computer) in which the student applies appropriate machine learning methods to the given data for a given problem of classification, grouping or linear regression and evaluates the obtained results (O1, O3, O5)

[12] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

• Practical test (colloquium on the computer) in which the student applies deep learning techniques to the given data and modifies the learning parameters and hyperparameters and evaluates the obtained results (O4, O5)
• A practical project task in which the student applies theoretical foundations and knowledge of machine or deep learning methods and creates a project according to predetermined instructions and evaluation criteria in which:

- designs a problem that can be solved using machine or deep learning, finds and prepares a dataset for learning and chooses an appropriate method and examines different parameters and learning methods to choose the model that gives the best result (O2, O5, O6).
- Prepares a written report on the project and experimental work, which will contain an analysis of the problem, a description of the data set used, a description of the architecture used, and an evaluation and explanation of the achieved results (O2, O5, O6, O7)
- The student will present the project and the obtained results (O5, O6, O7)

1.4. Mandatory literature (at the time of submission of study programme proposal)

1. Christopher M. Bishop (2007.), Pattern Recognition and Machine Learning, Springer
2. Ian Goodfellow and Yoshua Bengio and Aaron Courville: Deep Learning, The MIT Press, 2016. http://www.deeplearningbook.org/
3. Josh Patterson, Adam Gibson, Deep Learning, A practitioner's approach, O'Reilly Media, 2017. https://www.purestorage.com/content/dam/purestorage/pdf/whitepapers/oreilly-deep-learning-book.pdf

1.5. Optional/additional literature (at the time of submission of the study programme proposal)

1. Ethem Alpaydin (2020.), Introduction to Machine Learning, MIT Press
2. Kevin P. Murphy (2012.), Machine Learning, MIT Press
3. Nikhil Buduma, Nicholas Locascio (2017.), Fundamentals of Deep Learning, "O'Reilly Media, Inc."
4. Molnar, C.: Interpretable Machine Learning (2022), https://christophm.github.io/interpretable-ml-book/

1.6. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.7. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. Sanda Martinčić-Ipšić	
Name of the course	**Big Data Analytics**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1.	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The goal of the course is to develop a system for large-scale big data analytics by developing an architecture and analytic solution for a given problem: finding similar and/or frequent products, services, or users, stream processing, stream mining, monitoring advertising, recommending content or products or services, monitoring user opinions, converting unstructured content into a structured or semi-structured format, predicting new links/relationships/connections, monitoring trends in time series, etc.

1.2. Course enrolment requirements

Finished course: Big Data Infrastructure

1.3. Expected learning outcomes

It is expected that upon successful completion of the obligations in this course, the student will be able to:

O1. Design and construct data sets in a heterogeneous big data processing environment from the perspective of distributed, semi-structured, and unstructured data appropriate to the problem at hand, including relational databases and data warehouses, NoSQL databases, data lakes, ontologies and knowledge graphs.
O2. Conceptually and logically design a NoSQL database appropriate for one of the ways of recording key-values, columns, graphs, or documents and propose an implementation for a given problem.
O3. Propose and evaluate the implementation of a NoSQL database with the formulation of search queries in the appropriate paradigm for a given domain problem of large-scale data analysis.
O4. Critically evaluate technologies for working with heterogeneous, distributed, semi-structured and unstructured data, i.e. streaming data.
O5. Evaluation of real-time streaming data analytics system.
O6. Design and implement components of an intelligent information system based on big data using programming languages and tools that efficiently meet the requirements of the problem.
O7. Design, develop, and evaluate a solution to a selected big data analytics problem such as: finding similar and/or frequent items, products, services, or users, data analysis in an endless stream, monitoring advertising, recommending content or products or services, monitoring user opinions, converting unstructured content into a structured or semi-structured format, predicting new links, monitoring trends in time series, etc.

1.4. Course content

The content of the course consists of topics:

- Introduction to big data analytics, principles, platforms and ecosystems. Examples of applications. Sources and types of high-volume data. Definitions.
- Principles of processing and storing heterogeneous and distributed large-volume data. Organization of computer systems for applications based on large-scale data. CAP, BASE and ACID theorems.

- NoSQL databases based on key-value, column, document or graph for recording unstructured data.
- Information searches in NoSQL databases.
- Data lakes. Integration of databases and data warehouses with large volumes of data into a unique infrastructure for business analytics.
- Data integration for analytical purposes. Knowledge graphs.
- Batch methods of processing large-volume Map-Reduce data. SQL as Map-Reduce.
- Processing and analytics of endless streams of data. Real-time streaming data processing. Principles of data stream compression and analytics - Distributed data streams.
- Principles of Machine Learning for Big Data: Cloud Tools and Services
- Big data analytics for problems of finding similar and/or frequent products, services or users.
- Advertising tracking analytics, recommending content or products or services.
- Analytics, tracking user opinion, converting unstructured content into a structured or semi-structured format.
- Analytics for predicting new connections, tracking trends in time series and similar.
- Big data analytics trends.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	Instruction is delivered through a combination of face-to-face sessions (lectures and tutorials), individual assignments, and occasional industry-related seminars and workshops, as well as through the use of e-learning systems.	

1.7. Student responsibilities

The duties of students in this course are:

- Students are expected to attend class regularly, participate in all course activities, and follow course notifications in the e-learning system.
- In addition, the practical application of the acquired knowledge includes the development and creation of selected independent project work that involves developing /implementing a system for big data analysis on the installed infrastructure or cloud services for the selected problem.
- The student is also required to complete assignments during the semester (continuous monitoring of student work), create and present independent practical project work.
- The theoretical part of the course will be evaluated in the final exam with at least 50% of the points obtained.

The exact manner in which the course will be assessed and the thresholds for passing each assessment activity will be specified in the detailed syllabus of the course.

1.8. Monitoring of student work[13]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	***1***	Oral exam		Essay		Research	
Project		Continuous assessment	1	Report		Practical work	2
Portfolio							

[13] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- The theoretical portion of the course will be assessed in the final written or online exam, in which students must demonstrate their knowledge of Big Data analytics concepts by answering questions (e.g., multiple-choice questions, essay questions, solving a given problem or case) - to review O1, O2, O4, and O6.
- Independent hands-on project work that involves building a system for large-scale data analytics on installed infrastructure or cloud services for the chosen problem (finding similar and/or frequent products, services, or users, analysing data in an real time stream, monitoring advertising, recommending content or products or services, tracking user opinions, converting unstructured content into a structured or semi-structured format, predicting new connections, tracking trends in time series, etc.)
- O3, O5, and O7 will be examined, with the student demonstrating practical and theoretical application through specific practical project work and their presentation.
- Through continuous observation throughout the semester, students will create independent assignments on O1-O7.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition, 2020.
2. Nathan Marz and James Warren, Big Data: Principles and best practices of scalable realtime data systems, Manning Pub. 2015.
3. Andrew G. Psaltis: Streaming Data - Understanding the real-time pipeline, Manning Pub, 2017.
4. Dan McCreary, Ann Kelly Making Sense of NoSQL, 1st Edition, Manning, 2013.
5. 5. Guy Harrison, Next Generation Databases: NoSQL, NewSQL, and Big Data, Apress, 2015.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Dean Wampler, Fast Data Architectures for Streaming Applications, O'Reilly, 2016, http://www.oreilly.com/data/free/fast-data-architectures-for-streaming-applications.csp (17.2.2022.)
2. Scalable Systems for Big Data Analytics: A Technology Tutorial, IEEE, 2014. https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6842585
3. Dylan Scott, Viktor Gamov, Dave Klein, Kafka in Action, Manning, 2022. https://livebook.manning.com/book/kafka-in-action/
4. Jimmy Lin, Chris Dyer, Data-Intensive Text Processing with MapReduce, Morgan& Claypool, 2010

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition, 2020. http://www.mmds.org/#ver30 (17.2.2022.)	online	20
Nathan Marz and James Warren, Big Data: Principles and best practices of scalable realtime data systems, Manning Pub. 2015. https://www.manning.com/books/big-data (17.2.2022.)	2	20
Andrew G. Psaltis: Streaming Data - Understanding the real-time pipeline, Manning Pub, 2017. https://www.manning.com/books/streaming-data (17.2.2022.)	2	20
Dan McCreary, Ann Kelly Making Sense of NoSQL, 1st Edition, Manning, 2013. https://livebook.manning.com/book/making-sense-of-nosql/about-this-book/23 (17.2.2022.)	2	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. Ana Meštrović, PhD	
Name of the course	**Knowledge Representation and Reasoning**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to introduce formalisms for knowledge representation and reasoning. In addition, the objective is to provide an introduction to knowledge bases and introduces approaches to integrating data from heterogeneous knowledge sources. The course covers approaches to knowledge representation on the Web, ontologies, semantic Web, semantic technologies, and methods for collecting data from the Web and reasoning with such data.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Choose the appropriate formalism for knowledgre representation and reasoning depending on the characteristics of the given problem, and define a solution in the given representation formalism with the appropriate reasoning method.
O2. Critically evaluate the relationship between expressiveness and reasoning for the formalisms of knowledge representation and reasoning.
O3. Design a model for the knowledge base and implement a knowledge base for the given problem using appropriate programming languages and technologies.
O4. Choose methods and techniques for semantic integration of data from heterogeneous data sources and other knowledge bases.
O5. Develop and evaluate the application of knowledge bases in the given intelligent information systems.
O6. Formulate queries in query languages for various knowledge base technologies.
O7. Design a program using techniques based on symbolic logic (propositional logic, first-order logic, higher-order logic, frame-based logic, descriptive logic, constraint logic, etc.) and/or other formalisms (λ-calculus, π-calculus, grammars, finite automata, etc.).
O8. Design a solution in a declarative programming language using relational, logical, functional, distributed and/or meta-programming in tasks related to the application of formalisms for displaying knowledge and reasoning about knowledge.

1.4. Course content

The course includes the following topics:

- Knowledge. Classification of knowledge. Knowledge transformations. An overview of knowledge representation formalisms. Methods of reasoning about knowledge. The relationship between expressiveness and reasoning about knowledge. Application of formalisms to display knowledge and reasoning methods in different domains. Development of the knowledge bases. Structured data.

- Data collection techniques and heterogeneous data sources on the web (data crawling, data scraping). Integration of data from heterogeneous knowledge sources. Semantic technologies. Semantic interoperability. The Semantic Web. Knowledge representation on the web. Ontologies. Ontology languages.
- Application system of knowledge bases in the development of intelligent information systems. Methods for evaluation of knowledge-based systems. Query languages.
- Techniques based on symbolic logic (propositional logic, first-order logic, higher-order logic, frame-based logic, descriptive logic, constraint logic, etc.) and/or other formalisms (e.g. λ-calculus, π-calculus, grammars, finite machines, etc.). Overview of the application of relational, logical, functional, distributed and/or meta-programming in the development of systems for knowledge representation and reasoning about knowledge.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will work independently or as a team on a project assignment.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes and participate in all course activities and follow notifications related to classes in the e-learning system.
- Take the final exam and score at least 50% on it.
- Students' obligations include homework, colloquiums, seminars and project assignments.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[14]

Class attendance	2	Class participation		Seminar paper	0.5	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1.5	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written verification of related to formalisms for knowledge representation and reasoning. Example question: List and describe formalisms for representing knowledge. First colloquium in theory (O1, O2).
- Written verification related to knowledge bases. Example question: List the methods and techniques for semantic integration of data from heterogeneous sources. (O3, O4).
- Project: Develop and evaluate the system for application of knowledge bases in the development of intelligent of information systems - implement a chat agent (O5).
- Practical knowledge check: querying the knowledge base (O6).

[14] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- Final exam: written test of knowledge related to the declarative programming paradigm and logic. Example question: Explain the theoretical basis of lambda calculus (O7, O8).
- Practical part of the final exam - example: Design a program for reasoning about the data collected from heterogeneous data sources on the web using techniques based on symbolic logic (O7, O8).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2010).
2. Guarino, Nicola, and Pierdaniele Giaretta. "Ontologies and knowledge bases." Towards very large knowledge bases (1995): 1-2.
3. Ronald J. Brachman and Hector J. Levesque (2004.), Knowledge Representation and Reasoning, Morgan Kaufmann
4. Frank van Harmelen, Vladimir Lifschitz and Bruce Porter (Eds) (2008.), Handbook of Knowledge Representation, Elsevier Science
5. Content prepared for learning and published in Merlin

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. J. M. Firestone, M. W. McElroy (2003.), Key issues in the new knowledge management, KMCI Press: Butterworth-Heinemann, USA
2. Sowa, John F. Knowledge representation: logical, philosophical and computational foundations. Brooks/Cole Publishing Co., 1999.
3. Van Harmelen, F., Lifschitz, V. and Porter, B. eds., 2008. Handbook of knowledge representation. Elsevier.
4. Levesque, Hector J. "Knowledge representation and reasoning." Annual review of computer science 1, no. 1 (1986): 255-287.
5. Levesque, Hector J., and Gerhard Lakemeyer. The logic of knowledge bases. MIT Press, 2001.
6. Kifer, Michael, and Yanhong Annie Liu, eds. “Declarative logic programming: theory, systems, and applications.” Association for Computing Machinery and Morgan & Claypool, 2018

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Russell, Stuart, and Peter Norvig. "Artificial intelligence: a modern approach." (2010.).	4	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assoc. Prof. Sanja Čandrlić, PhD	
Name of the course	**Software Engineering**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION
1.1. Course objectives
The objective of the course is to acquire knowledge in the field of software engineering, which includes requirements analysis, project development, team software development and its testing. It includes application of methods, techniques, and approaches that help planning, team organization, and task management during software development in a given time and with given resources.
1.2. Course enrolment requirements
There are no enrolment requirements for this course.
1.3. Expected learning outcomes
It is expected that after completing all assignments prescribed in the course, students will be able to: O1. Distinguish basic concepts, methods and techniques and approaches in the field of software engineering, especially related to traditional and agile approaches. O2. Develop models of a system based on an analysis of user requirements and market needs in a given domain. O3. Estimate the resources needed to create the software. O4. Plan software development with different roles of development team members and users in a team project of software development. O5. Based on the analysis performed and the project created, create the software in the selected development tool and prepare its documentation. O6. Perform tests based on the planned test cases and document the test results.
1.4. Course content
• Software engineering as a discipline. Traditional, agile and hybrid approach to software development. Models of software development. Methods and techniques in different phases of software development. Team management. Management of user requirements. Estimating resources for software development. Risk management. User experience. System models. Software product architecture. CASE tools. Implementation. Construction of program code in collaboration. Refactoring. Testing. Version management. Software documentation. Professional responsibilities of software engineers. Program reengineering.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-	

	learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, practical work, project activities, seminar paper) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[15]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project	2	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assessment of the set of learning outcomes is done through continuous knowledge review, practical work and project assignment:

- In the written exam students demonstrate an understanding of the theoretical concepts, procedures, methods, and approaches of software engineering (O1). For example, they explain the characteristics, advantages and disadvantages of an agile approach to software development.
- Practical work includes working in a team to analyse user requirements and market requirements for a specific domain, creating a system model (O2), and estimating the resources needed to create software (O3). For example, it is necessary to define what needs to be done during software development and estimate the time required to perform these tasks.
- The project (final exam) includes the continuous planning of tasks in the software development team (O4), the creation of the software and software documentation (O5), and the creation of a test plan and its implementation (O6). For example, to create test cases and test scenarios for a specific system module.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Van Vliet, H.: Software Engineering - Principles and Practice, Third Edition. John Wiley and Sons, Chicester UK, 2008.
2. Farley, D. Modern Software Engineering: Doing What Works to Build Better Software Faster, Addison-Wesley Professional, 2022.
3. Pressman, R., Maxim, B. R. Software Engineering: A Practitioner's Approach, McGraw Hill, 2019.
4. Wysocki, R. K., Effective project management : traditional, agile, extreme, Wiley Publishing, 2014.
5. Content prepared for learning through the learning system.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

[15] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1. Sommerville, I.: Software Engineering, 10th Edition, Pearson, 2015.
2. Thomas, D., Hunt, A. The Pragmatic Programmer: your journey to mastery, Pearson, 2019.
3. Martin, R. C. Clean Agile: Back to Basics, Pearson, 2019.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Farley, D. Modern Software Engineering: Doing What Works to Build Better Software Faster	1	20
Wysocki, R. K., Effective project management : traditional, agile, extreme	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Danijela Jakšić, PhD	
Name of the course	**Digital Marketing**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire basic and extended knowledge in the field of digital marketing. These skills include, among other things, the effective use of methods, procedures and tools for planning and executing a digital marketing campaign, creating content for content marketing, managing social network marketing and search engine marketing, and performing marketing optimization and analytics.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Distinguish the basic concepts, procedures, methods and techniques of digital marketing.
O2. Analyse different scenarios and practices of planning and managing basic digital marketing strategies: content marketing, social media marketing, e-mail marketing, search engine marketing, marketing optimization, marketing analytics.
O3. Evaluate the digital marketing strategy for a selected business example and case study.
O4. Apply methods, techniques and tools for managing a digital marketing strategy and executing a marketing campaign, based on market research, monitoring trends and examples of good practice.
O5. Plan and implement a complete digital marketing campaign for your own project in the chosen domain, according to the rules of the profession and good practice.
O6. Analyse the success of the digital marketing campaign, using selected tools, procedures and methods for marketing analytics.
O7. Recreate the elements, strategies and phases of a digital marketing campaign for its greater success, based on the knowledge obtained using the selected tools, procedures and methods for marketing optimization (SEO) and marketing analytics.

1.4. Course content

The course includes the following topics:

- Market research and marketing innovation. Psychology and consumer behaviour in the digital world. Brand and reputation management. Global trends in digital marketing.
- Concepts and principles of digital and internet marketing. Types of digital and internet marketing. Channels for digital marketing. Analysis and development of digital marketing strategies. Analysis and creation of a marketing plan and marketing mix.
- Design of visual communications and digital tools for visual communications. Media communications.
- Content marketing. Life cycle and content types (TOFU, MOFU, BOFU). Copywriting. Content Writing. Digital tools for content marketing. Content creation for content marketing.

- Social media marketing. Types of social networks. Social listening. Social influence. Social networking. Social selling. Digital tools for social media marketing. Creating content for social network marketing.
- E-mail marketing. Digital tools for e-mail marketing. Creating content for e-mail marketing.
- Search Engine Marketing (SEM). Digital tools for search engine marketing. Creating content for search engine marketing.
- Online public relations. Digital advertising. Digital branding. Digital tools for online advertising and branding. Creating content for online public relations. Creation of content for digital advertising.
- Marketing optimization (Search Engine Optimization – SEO). Digital tools for marketing optimization. Procedures, methods and techniques for marketing optimization. Application of tools and procedures for marketing optimization on own and selected examples.
- Marketing analytics. Measuring the success of digital marketing. Procedures, methods and techniques for marketing analytics. Digital tools for marketing analytics. Application of tools and procedures for marketing analytics on own and selected examples.
- Digital marketing campaigns, case studies and examples of good practice for: online and electronic businesses, web projects, software projects and applications, social media and digital communications.
- Planning, management and execution of a complete digital marketing campaign for own ICT product (software, application).

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (homework/activities in class, practical work, seminar paper and continuous assessment) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[16]

Class attendance	2	Class participation	0.5	Seminar paper	1	Experimental work	
Written exam		Oral exam	0.5	Essay		Research	
Project		Continuous assessment	0.5	Report		Practical work	1.5

[16] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assesment of the set of learning outcomes is done through activities in class and/or homework, continuous assessment, preparation of a seminar paper, doing the practical work (project assignment) and its oral presentation:

- At the continuous assessment activity, student demonstrates an understanding of theoretical concepts, procedures, methods and techniques of digital marketing (O1). For example, explain the difference between TOFU, MOFU and BOFU content, or what is the basic difference between the best metrics for social media marketing and search engine marketing.
- In class activities and/or homework, student analyses different scenarios and practices of planning and managing basic digital marketing strategies (O2) and applies methods, techniques and tools for selecting and implementing application software for managing digital marketing strategies and executing marketing campaigns (O4). For example, find and review examples of good and bad e-mail marketing practices, or try and review the advantages and disadvantages of using the chosen digital tool for marketing optimization.
- Seminar paper includes the evaluation of the digital marketing strategy for a selected business example and case study (O3). For example, write a seminar paper on the topic "A critical review of the digital marketing campaign and social network marketing strategy for Nike".
- Practical work (project) includes planning and implementation of a complete digital marketing campaign for one's own project in the chosen domain, according to all the rules of the profession and good practice (O5), analysis of the success of the digital marketing campaign, using selected tools, procedures and methods for marketing analytics (O6) and recreating the elements, strategies and phases of a digital marketing campaign for its greater success, based on the knowledge obtained using selected tools, procedures and methods for marketing optimization (O7). For example, create, implement, evaluate and improve the digital marketing campaign for the "DINPomat Mobile Application" project and present it in the oral exam.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Chaffey, D., Ellis-Chadwick, F. (2019). Digital marketing: strategy, implementation and practice. Pearson, United Kingdom.
2. Hartman, K. (2020). Digital Marketing Analytics: In Theory And In Practice. Independently published.
3. Clarke, A. (2021). SEO 2022 Learn Search Engine Optimization With Smart Internet Marketing Strategies: Learn SEO with smart internet marketing strategies. Independently published.
4. Prepared learning materials available through the system for distance learning

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Smith, P. R., Zook, Z. (2019). Marketing Communications: Integrating Online and Offline, Customer Engagement and Digital Technologies. Kogan Page.
2. Kingsnorth, S. (2019). Digital Marketing Strategy: An Integrated Approach to Online Marketing. Kogan Page.
3. McGruer, D. (2020). Dynamic Digital Marketing: Master the World of Online and Social Media Marketing to Grow Your Business. Wiley.
4. Stanton, P. (2018). Conscious Creativity Look. Connect. Create. Leaping Hare Press.
5. Clay, B., Jones, K. B. (2022). Search Engine Optimization All-in-One For Dummies. For Dummies.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Chaffey, D., Ellis-Chadwick, F. (2019). Digital marketing: strategy, implementation and practice. Pearson, United Kingdom.	1	20

Hartman, K. (2020). Digital Marketing Analytics: In Theory And In Practice. Independently published.	1	20
Clarke, A. (2021). SEO 2022 Learn Search Engine Optimization With Smart Internet Marketing Strategies: Learn SEO with smart internet marketing strategies. Independently published.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Full Prof. Patrizia Poščić, PhD	
Name of the course	**Managing digital Transformation**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is the acquisition of basic and extended knowledge in the field of management and digital transformation, which includes knowledge of basic concepts, methods and techniques in the development, implementation and management of various business systems. It includes also, the effective use of concepts, methods, management and decision-making techniques in an organization that is undergoing digital transformation and assessment of the organization's readiness to implement digital transformation changes.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Distinguish basic concepts, methods, techniques and approaches to company management in the process of digital transformation.

O2. Propose the making of managerial decisions, including the selection and advocacy of why the chosen strategy is appropriate, based on the analysis of business cases of companies undergoing the process of digital transformation.

O3. Propose a solution to a real decision-making problem by applying methods and software tools for multi-criteria decision-making based on a previously conducted evaluation of existing examples from practice.

O4. Distinguish basic concepts, methods, techniques, standards and approaches in the development, implementation and management of various business systems (ERP, CRM, etc.)

O5. Evaluate a complete commercially available information system for a selected business example.

O6. Create a business process improvement project implementation plan based on an assessment of the organization's readiness to implement changes, an assessment of the costs and effects of business process improvement, a designed system for measuring the effectiveness of process performance, and an analysis of financial, human, information and other resources.

1.4. Course content

- Basics of management. Management levels and managerial decisions.
- The term and concept of digital transformation.
- The decision problem and the elements of the decision problem. Multi-criteria decision-making and methods for multi-criteria decision-making (AHP, ELECTRE, PROMETHEE). Game theory.
- Introduction to ERP systems. Implementation and methodology of the ERP system. Tools for complete management of the organization.
- Introduction to customer relationship management. CRM information system.

- Development of a performance measurement management model. Measuring instruments of the BSC model. Metamodel of measuring

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will be instructed to use the distance learning system immediately after enrolling into this course. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, homeworks, practical work, project activities, seminar paper) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[17]

Class attendance	2	Class participation	2	Seminar paper		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assesment of the set of learning outcomes is done through class activities and/or forum discussions, homeworks, doing the practical work (project assignment) and taking the final exam:

- During class activities and/or forum discussion, student analyses business cases of companies undergoing the process of digital transformation (O2). For example, for a given business case of a company undergoing a digital transformation process, determine a suitable strategy and justify the choice.
- In the written final exam, student demonstrates an understanding of the concepts, methods, techniques and approaches to company management in the process of digital transformation (O1) and an understanding of the differences in the development, implementation and management of various business systems (O4). For example, explain the concept of digital transformation, or describe the phases of ERP system introduction.
- During class activities and/or homework includes creating a solution to a real decision-making problem using methods and software tools for multi-criteria decision-making (O3) and evaluating a complete

[17] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

commercially available information system for a selected business example (O5). For example, solve the business problem of deciding on a market presence strategy by applying one of the multi-criteria decision-making methods or analyze the purchasing department in the ERP tool on the given example of company X.

- Practical work includes the creation of a plan for the implementation of the business process improvement project (O6). For example, carry out an assessment of the readiness of the chosen organization to implement changes, taking into account the costs and effects of improving business processes, and create an improvement implementation plan.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Bradford, M. (2020).Modern ERP: Select, Implement, and Use Today's Advanced Business Systems, Poole College of Management, North Carolina State University, Raleigh NC.
2. Čičin-Šain, D. (2009). Osnove menadžmenta (digitalna skripta), Visoka škola za turistički menadžment, Šibenik.
3. Fatouretchi, M. (2019).The Art of CRM: Proven strategies for modern customer relationship management, Packt, Birmingham – Mumbai.
4. Noven, P. R. (2007). Balanced scorecard korak po korak: maksimiziranje učinaka i održavanje rezultata. Masmedia, Zagreb.
5. Sikavica, P., Hunjak, T., Begičević Ređep, N., Hernaus, T. (2014). Poslovno odlučivanje. Školska knjiga, Zagreb.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Buble, M. (2005). Strateški menadžment. Sinergija, Zagreb.
2. Dyche, J., Diche, J. (2001). The CRM handbook: A business guide to customer relationship management. Addison-Wesley, Boston.
3. Garača, Ž. (2009). ERP sustavi. Split: Sveučilište u Splitu, Ekonomski fakultet u Splitu.
4. Norton, R.S., Kaplan, D.P. (2001).The Strategy-Focused Organizations: how balanced scorecard companies thrive in the new business enviroment. Harvard Business School, Boston.
5. O'Leary, D.E. (2000). Enterprise Resource Planning Systems: Systems, Life Cycle, Electronic Commerce, and Risk. Cambridge University Press.
6. Sikavica, P., Bahtijarević-Šiber, F., Pološki Vokić, N. (2008). Temelji menadžmenta, Školska knjiga, Zagreb.
7. Vranešević, T. (2000). Upravljanje zadovoljstvom klijenata. Golden marketing - Tehnička knjiga, Zagreb.
8. Žugaj, M., Schatten, M. (2005). Arhitektura suvremenih organizacija. Tonimir, Varaždinske Toplice.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Sikavica, P., Hunjak, T., Begičević Ređep, N., Hernaus, T. (2014). Poslovno odlučivanje. Školska knjiga, Zagreb.	4	20
Noven, P. R. (2007). Balanced scorecard korak po korak: maksimiziranje učinaka i održavanje rezultata. Masmedia, Zagreb.	1	20
Vranešević, T. (2000). Upravljanje zadovoljstvom klijenata. Golden marketing - Tehnička knjiga, Zagreb.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Martina Holenko Dlab, PhD	
Name of the course	**3D Computer Modelling**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire knowledge in the field of computer graphics about the concepts and techniques of 3D computer modelling and the skills to create graphical representations and models for various applications (computer game development, digital marketing, e-learning, 3D printing, etc.).

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Describe various techniques of 3D computer modelling, drawing methods, and techniques for speeding up rendering.
O2. Analyse the quality and degree of complexity of 3D models.
O3. Create realistic virtual objects.
O4. Create procedural and fractal models of nature.
O5. Create realistic virtual scenes using textures, lighting models, and special effects.
O6. Select appropriate software support for creating 3D models and graphical representations for various applications (computer games, marketing, education, 3D printing, etc.).

1.4. Course content

The course includes the following topics:

- Types and techniques of 3D computer modelling (polygonal modelling, NURBS, subdivision modelling).
- Advanced rendering methods (ray tracing)
- Rendering acceleration (polygon count reduction, selective discard, level-of-detail techniques, optimal polygon structures, scene organization, and state changes)
- Texturing and lighting of 3D models
- Special rendering effects: generalized texturing, texture filtering, transparency mapping, lighting, gloss, mirroring, roughness.
- Softening effects, shadows, fog, panel techniques and other effects.
- Modelling of virtual characters (parametric surfaces, division surfaces, polygon meshes).
- Creation of virtual character models (manual digitizing, photogrammetry, laser scanning, and modification of existing models).
- Procedural textures and models
- Fractal modelling
- Creation of 3D models for various applications (computer games, marketing, education, 3D printing, etc.).

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in practical problem-solving tasks during lectures and auditory and/or laboratory exercises.
- Participate in continuous assessment activities (theoretical preliminary exams) and successfully complete them.
- Publish graphic content created during the course in portfolio.
- Take the final exam and achieve at least 50% of the points.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[18]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam	0.5	Essay		Research	
Project	0.5	Continuous assessment	1	Report		Practical work	1.5
Portfolio	0.5						

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

Written exam (online quiz) in which the student demonstrates understanding of the theoretical concepts of 3D modelling and design, e.g., multiple-choice questions, completion questions, and essay questions (O1, O2).
Practical assignments in which the student demonstrates an understanding of the theoretical and practical concepts involved in creating 3D representations of objects using appropriate software (O2, O3, O4, O5).
A practical project assignment in which the student demonstrates an understanding of all theoretical and practical material covered in the course. Simultaneously, the student models 3D representations for a specific application using appropriate software support (O1, O2, O3, O4, O5, O6).
A portfolio containing graphic content created as part of the course. The completeness and quality of the content published in the portfolio will be evaluated according to previously developed criteria (O3, O4, O6).

1.10. Mandatory literature (at the time of submission of study programme proposal)

[18] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1. Angel, E. Shreiner, D.: Interactive Computer Graphics: A Top-Down Approach with WebGL (7th Edition) (2015.), Pearson Education, Inc., publishing
2. Prepared learning materials available through the system for distance learning.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Hughes, F. J. et al. (2014). Computer graphics: principles and practice (3rd edition). Upper Saddle River, NJ: Addison-Wesley.
2. Musgrave, F.K., Peachey, D., Perlin, K. and Worley, S., (2003). Texturing and modeling: a procedural approach (3rd edition). Academic Press Professional, Inc.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. M. Pobar, PhD	
Name of the course	**Development of 3D games**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	2+2+0

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to adopt basic concepts on the development and design of 3D computer games. Students will be trained to independently design a computer game by applying basic design principles and practical knowledge about the development of computer games by determining its content, goal, and rules, and to develop its prototype in a development environment for creating computer games and interactive content.

1.2. Course enrolment requirements

None

1.3. Expected learning outcomes

It is expected that after successfully fulfilling the obligations in the course, the student will be able to:

O1. Create a game design document for their own 3D computer game.

O2. Create the elements of a 3D environment within the development environment for creating computer games and interactive content (terrain, camera, light, sky, objects, interface, materials, shaders, visual effects).

O3. Manage external resources (3D models, textures, animations, sound, ...) .

O4. Implement the mechanics and fundamental functionality of the game (movement of objects, interaction, collision detection, progress through play, procedural generation) using the appropriate programming language or physical and mathematical models.

O5. Integrate appropriate AI algorithms into the game (e.g. for the behavior of a computer opponent).

O6. Develop and document a prototype of their own 3D computer game.

1.4. Course content

- Introduction to the analysis, design and development of computer games.
- The structure and formal elements of a game. Game design document.
- Development environments for creating 3D games and interactive content (game engines).
- Working with external resources (import and integration of 3d models, textures, animations, sound...)
- Scripting, character management and interaction.
- Physical simulations (collision detection, gravity, movement).
- Creating and managing graphical elements of the scene (3D objects, characters, terrain, sky, particle systems, ...)
- The rendering pipeline. 3D environment, camera and lights.

- Visual effects, shaders and postprocessing.
- Animation of 3D characters.
- Sound effects and music.
- Applying AI algorithms (computer character behavior, pathfinding)
- Procedural generation of game elements (e.g. terrain, individual objects, levels)
- Game testing. Performance optimization.
- Analysis of design and implementation of 3D computer games of different genres.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	All materials from lectures and exercises, useful links and literature, information related to the performance of the course as well as spaces for delivering the project results are available to students through the e-learning system. The course combines classroom work when adopting concepts and team project work during the creation of project assignment.	

1.7. Student responsibilities

Students are expected to:

- Regularly attend classes, participate in all course activities regularly follow the notices in the e-learning system
- Attend the continuous assessment activities (practical tests)
- Design and create a practical project that involves creating a game design document, prototyping a 3D computer game and a final report.
- To take the final exam in which the project is presented and defended and achieve at least 50% of the points on it.
- Scoring criteria and any thresholds for individual evaluation activities will be detailed in the course syllabus.

1.8. Monitoring of student work[19]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment	1	Report		Practical work	2
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Practical test in which a student creates or integrates the given elements of the 3D environment in a given scene in the game engine.
- Practical test of knowledge in which a student implements the given mechanics and functioning of the game in a given scene in the game engine
- A practical project task in which the student applies theoretical knowledge and skills of developing 3d computer games for creation of the project according to predetermined instructions and evaluation criteria. The project task includes:

[19] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- Creation of a game design document in which one's own idea for a 3D computer game is elaborated (O1)
- Developing a prototype of their own 3D computer game (O2-O6)
- Preparation of the final report and presentation of the project (O1, O6)

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. J. Gibson Bond: Introduction to Game Design, Prototyping, and Development: From Concept to Playable Game with Unity and C#, 2nd edition, Addison-Wesley, 2017
2. Nicolas Alejandro Borromeo: Hands-On Unity 2021 Game Development, 2nd edition, Packt, 2021
3. I. Millington: Artificial Intelligence for Games (The Morgan Kaufmann Series in Interactive 3D Technology) 1st Edition, 2006

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. John P. Doran: Unity 2021 Shaders and Effects Cookbook: Over 50 recipes to help you transform your game into a visually stunning masterpiece, 4th Edition, Packt, 2021
2. Mat Buckland: Programming Game AI by Example, Wordware, 2004
3. David Baron: Game Development Patterns with Unity 2021: Explore practical game development using software design patterns and best practices in Unity and C#, 2nd ed., Packt, 2021.
4. S. Rogers: Level Up!: The Guide to Great Video Game Design John Wiley & Sons, 2010.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assoc. Prof. Sanja Čandrlić, PhD	
Name of the course	**Interaction Design**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire knowledge in the field of interactive systems design, and it covers the whole process, starting from the idea, through the analysis of the users and the tasks that they will perform with the interactive system, planning their activity in the system, up to the creation of a functional prototype of the interactive system and analysis and evaluation of user experience and usability of the interactive system.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

It is expected that after completing all assignments prescribed by the course, students will be able to:
O1. Evaluate and critically assess theoretical concepts, methods and approaches in the field of interactive systems design.
O2. Conduct an analysis of requirements, users and their tasks for an interactive system.
O3. Based on the analysis, determine the elements of the user interface and user experience for the interactive system.
O4. Design user interface of an interactive system and use appropriate media components
O5. Design user experience of an interactive system
O6. Create a functional prototype of an interactive system.
O7. Evaluate user experience and test usability of the interactive system.

1.4. Course content

- User-product interaction design. User-centred design, PACT: people, activities, context, technology. Five dimensions of interaction design: words, visual representation, physical object and interaction space, time, and behaviour (action and reaction). Fundamentals of interactive systems design (memory, attention, action, emotion, action, social interaction, perception and navigation). User centred design and development of interactive systems: research, definition, design, evaluation, iterative approach. Use of personas and scenarios. Interaction design goals: usability, accessibility, experience design. Design principles. Multimodal interface design.
- Interactive systems design techniques: understanding requirements, user requirements elicitation methods, prototype, conceptual design, metaphors, physical design, interaction design. Analysis of tasks and actions. Usability evaluation. Usability evaluation methods. Interaction with business systems. Features of different interactive systems: the ubiquitous computing paradigm, social networks, applications and websites, collaborative environments, artificial intelligence, agents and avatars, mobile technology, wearable technology.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops	☒ individual assignments ☐ multimedia and network

	☒ exercises ☒ distance learning ☐ fieldwork	☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, practical work, project activities, seminar paper) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[20]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	0,5	Oral exam		Essay		Research	
Project	1	Continuous assessment	0,5	Report		Practical work	2
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assessment of the set of learning outcomes is done through continuous knowledge review, written exam or paper, practical work and project assignment:

- In the written exam or paper students demonstrate an understanding of the theoretical concepts, methods, and approaches in the field of interactive systems design (O1). For example, they explain the user-centred design process of interactive systems.
- The practical work includes independent or team work related to the practical application of appropriate methods for the analysis of requirements, users and their tasks for the interactive system (O2) and the design of the user interface according to the analysis performed, including appropriate elements and media components (O3, O4). As part of the practical assignment, the student will design user experience for the given interactive system (O5).
- As part of the practical assignment, students will evaluate the user experience and test usability of an interactive system (O7), i.e., the design of a prototype as part of the design process of a new system and/or as part of the redesign of an existing selected or specified system. This practical assignment includes a proposal for necessary improvements to the interactive system based on the evaluation performed.
- As part of the project (final exam), students independently or in a team create a functional prototype of an interactive system (O6).

1.10. Mandatory literature (at the time of submission of study programme proposal)

[20] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1. Jenny Preece, Yvonne Rogers & Helen Sharp. Interaction Design: Beyond Human-Computer Interaction, John Wiley and Sons, 2019.
2. David Benyon. Designing User Experience. A guide to HCI, UX and interaction design, Pearson, 2019.
3. Jesse James Garrett. The Elements of User Experience, Pearson, 2011.
4. Content prepared for learning through the learning system.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Bill Buxton. Sketching User Experiences – getting the design right and the right design, Morgan Kaufman, 2007.
2. Susan M. Weinschenk. 100 Things Every Designer Needs to Know About People, New Riders, 2011.
3. Steve Portigal. Interviewing Users: How to Uncover Compelling Insights, Louis Rosenfeld, 2013.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Jesse James Garrett. The Elements of User Experience, Pearson, 2011.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Vanja Slavuj, PhD	
Name of the course	**Computer Forensics**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to introduce students to methods and techniques of computer forensics and enable them to conduct forensic investigations, including gathering, managing, and analysing digital traces by applying appropriate software and hardware tools in incidents related to information and communication technology.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Discuss legal and other regulations pertaining to the field of digital forensics in order to ensure privacy, maintain security, and protect data in information systems, as well as their enforcement in practice.

O2. Carry out methods for collecting relevant data (digital traces) in cases of security incidents, based on the principles of computer forensics.

O3. Examine and reconstruct digital data and events in cases of misuse of information and communication technology by applying software and hardware solutions of choice.

O4. Prepare a report and opinion regarding a security incident by following a set procedure for tracking and reporting incidents and their consequences.

O5. Suggest a procedure for ensuring and improving security in a business environment, including a policy for data protection, data access, as well as creation, storage, and use of backup data.

O6. Research relevant sources (journals, forums, specialised reports, etc.) and new insights and trends in developing information and communication systems, with a special emphasis on the infrastructure, platforms, and applications, and their use in computer forensics.

1.4. Course content

The course includes the following topics:

- Basic concepts of computer forensics and related procedures. Security incidents management. Investigation phases. Computer forensics applications. Ethical issues in computer forensics.
- Forensic investigation procedures. Evidence gathering and analysis. Computer forensics laboratory and its organisation. Preparation of documentation (reports, logs, protocols, etc.) for the management.
- Legal and other regulations related to computer forensics. Evidence organisation and storage. Evidence preparation and presentation.
- Application of digital forensics tools. Analysis of storage media and recovery of missing data. Creation of image files, secure data deletion, backup files.

- Operating systems digital forensics. Filesystem and partition analysis. Event logs. Computer boot sector. Data categories and metadata. Working with files.
- Multimedia forensics. Determining graphics file integrity. Active and passive authentication of graphics files. Steganography.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in practical problem-solving tasks during lectures and auditory and/or laboratory exercises.
- Participate in continuous assessment activities (theoretical preliminary exams) and successfully complete them.
- Complete a project assignment on a given topic and regularly document its development. This activity requires the student to achieve a minimal set number of points (threshold).
- Prepare a seminar paper on a given topic, as part of the final exam, and present it to the course instructor in an oral exam. This activity requires the student to achieve at least 50% of the overall number of points for this activity.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[21]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam	0.5	Essay		Research	
Project		Continuous assessment	1	Report		Practical work	1.5
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written test (theoretical preliminary exam) in which students demonstrate their understanding of the basic theoretical concepts related to computer forensics and forensic procedures, investigation and analysis procedures, and legal regulations, and which may include recall type-tasks, multiple choice tasks, matching tasks, essay questions, and extended response items – O1, O2, O4.
- Practical project assignment related to the application of software and hardware tools for digital forensics procedures (e.g., carry out a forensic analysis of a particular case of security incident and

[21] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

misuse of information and communication technology; conduct digital trace analysis and enforce measures for dealing with an incident, etc.) – O2, O3, O4.
Seminar paper (e.g., a case study, research work, etc.) on a topic related to practical applications of forensic analysis and procedures for ensuring and improving security aspects in an organisation – O5, O6.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Johansen, G. (2020). *Digital forensics and incident response* (2nd ed.). Packt Publishing.
2. Nelson, B., Phillips, A., & Steuart, C. (2019). *Guide to computer forensics and investigations*. Cengage.
3. Sammons, J. (2015). *The basics of digital forensics: The premier for getting started in digital forensics* (2nd ed.). Syngress.
4. Prepared learning materials available through the system for distance learning

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Hayes, D. R. (2020). *A practical guide to digital forensics investigations* (2nd ed.). Pearson Education Inc.
2. Kruse, W. G., & Heiser, J. G. (2010). *Computer forensics: Incident response essentials*. Addison-Wesley.
3. Maras, M.-H. (2015). *Computer forensics: Cyber criminals, laws, and evidence*. Jones & Bartlett Learning.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Digital forensics and incident response (2nd ed.)	1	20
Guide to computer forensics and investigations	1	20
The basics of digital forensics: The premier for getting started in digital forensics (2nd ed.)	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. Maja Matetić, PhD	
Name of the course	**Analysis of Sensor Data**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	1st	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objectives of the course include an introduction to the ubiquitous paradigm of the Internet of Things (IoT) which is defined as "a network of physical things embedded with sensors connected to the Internet" and requires an understanding of the embedded software, sensors and data analytics. The goal is that through practical work and project assignments, students gain experience in sensor data analysis.

1.2. Course enrolment requirements

Attended subject Data Mining.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:
O1. Identify fundamental IoT protocols, algorithms and architectures
O2. To illustrate the application of data analytics procedures and technologies for the improvement of IoT systems
O3. Perform exploratory analysis of sensor data based on its properties in the context of the request applications
O4. Choose appropriate methods for preparing sensor data
O5. Select and apply analytical methods of sensor data on a potentially large amount of data such as data flow
O6. Evaluate and present the results of sensor data analysis

1.4. Course content

The course includes the following topics:
- IoT network architecture and design. Smart objects: "Things" in the Internet of Things.
- Connecting smart objects. Data and Analytics for IoT.
- Basic properties of sensor data and sensor metadata. Sensor data stored in database.
- Sensor data flowing from a real-time data stream. Preparation of sensor data.
- Integration of sensor data with data from other modalities. "Internet of people", wearable technologies.
- Cloud computing and visualization of sensor data.
- Methods for analysing sensor data: learning descriptive and predictive models, detection anomaly.
- Individual student projects: Selection of a set or flow of sensor data and the problem to be solved by applying sensor data analysis, choosing a suitable data preparation procedure and data analysis procedure.

1.5. Manner of instruction

☒ lectures	☒ individual assignments
☒ seminars and workshops	☐ multimedia and network
☒ exercises	☐ laboratories
☒ distance learning	☒ mentorship

	☐ fieldwork	☐ other
1.6. Comments		

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly attend classes and participate in all course activities and follow notifications related to classes in the e-learning system.
- Take the final exam and score at least 50% on it.
- Students' obligations include homework, tests, seminars and project assignments.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[22]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Understanding of the theoretical basis related to the analysis of sensor data will be evaluated in the form of a seminar paper (O1, O2), for example with an emphasis on a specific machine learning procedure in model design.
- Practical work (exercises, exams and homework) will continuously evaluate the acquisition of knowledge regarding application of sensor data analysis procedures (O3-O5), for example in individual or team work in the application of data analysis on sensor data from various domains.
- The final project will consist of a complete analytical pipeline that starts with data download and ends with report and presentation (O3-O6), for example, individually or as a team, students will investigate an initial hypothesis by applying several machine learning methods on sensor data with evaluation and interpretation of results.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Hassan, Qusay F., ed. Internet of things A to Z: technologies and applications. John Wiley & Sons, 2018.
2. Geng, Hwaiyu, ed. Internet of things and data analytics handbook. John Wiley & Sons, 2017.
3. Hanes, David, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, and Jerome Henry. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. Cisco Press, 2017.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Kocovic, Petar, Reinhold Behringer, Muthu Ramachandran, and Radomir Mihajlovic, eds. Emerging trends and applications of the internet of things. IGI Global, 2017.
2. Joao Gama and Mohamed M. Gaber (eds.): Learning from Data Streams, Springer, 2007. Charu C. Aggarwal (ed.): Managing and Mining Sensor Data, 2013, Springer.Hair J.F. et al. Multivariate Data Analysis, 7th Edition, Pearson, 2014.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

[22] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Title	*Number of copies*	*Number of students*
Hassan, Qusay F., ed. Internet of things A to Z: technologies and applications. John Wiley & Sons, 2018.	2	20
Geng, Hwaiyu, ed. Internet of things and data analytics handbook. John Wiley & Sons, 2017.	2	20
Hanes, David, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, and Jerome Henry. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. Cisco Press, 2017.	2	20
1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).		

General information		
Course instructor	Prof. Sanda Martinčić-Ipšić, PhD/Assist. Prof. M. Pobar, PhD	
Name of the course	**Intelligent Information Systems**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	2+2+0

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to gain theoretical and practical knowledge and skills in the field of design, development and implementation of intelligent information systems in different application domains.

1.2. Course enrolment requirements

Machine and Deep Learning Course

1.3. Expected learning outcomes

It is expected that after successfully fulfilling the obligations in the course, the student will be able to:

O1. Propose an implementation concept of an intelligent information system in a specific field of application (e.g. finance, telecommunications, banking, retail, production, distribution) aligned with the needs and expectations of clients and with relevant laws, licenses and ethical standards.
O2. Recommend the architecture of an intelligent information system with the selection of the right technology, platform and tools for the development and implementation of intelligent information systems.
O3. Build a prototype intelligent information system based on the proposed architecture model with the integration of intelligent system components (machine learning, agent models and the like).
O4. Evaluate and choose the tools for monitoring, testing and administration of intelligent information systems.
O5. Design and conduct testing of the intelligent information system and its acceptability in relation to the set requirements.
O6. Develop the project and technical documentation of an intelligent information system.

1.4. Course content

- Introduction to Intelligent Information Systems engineering. The process of developing an intelligent IS. IIS Architecture. Platforms and tools. Agent systems and machine learning models. MLOps. Development of machine learning models. Metrics for model testing. Testing, collecting feedback, and error managing errors. Model iteration and versioning. Management of machine learning models. Continuous validation, optimization, and integration of machine learning models. Preparing for the production environment. Integration of service APIs. Production platforms in the cloud. Systems in the production environment. Scaling the system. Legal and ethical norms. Business domain case study for high-volume text analytics or data analytics. Case study in computer vision applications. Case study in the business domain e.g. finance, telecommunications, banking, retail, manufacturing, distribution.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☐ seminars and workshops	☐ multimedia and network
	☒ exercises	☐ laboratories
	☐ distance learning	☐ mentorship

	☐ fieldwork	☐ other
1.6. Comments		

1.7. Student responsibilities

Students are expected to regularly attend classes, participate in all course activities and regularly follow the notices in the e-learning system. During the semester, students have obligatory practical assignments for continuous assessment. During the semester, students also make a project assignment that involves the development of prototypes and documentation of an intelligent information system from the selected application domain. The project solution should also be presented. Scoring criteria and any thresholds for individual evaluation activities will be detailed in the course syllabus.

1.8. Monitoring of student work[23]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project	2	Continuous assessment	1	Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- The theoretical part of the subject is checked in the final written or online exam, in which the student is asked to show knowledge of the concepts of intelligent information systems with an emphasis on the verification of O1, O2, O4 by answering questions (e.g. multiple choice questions, essay questions, solving a given task or case).
- Individual practical project, which includes the development of a prototype and documentation of the intelligent information system from the selected application domain of application, pertains to O3, O4, O6 where the student will show practical and theoretical application through dedicated practical work and presentation of results.
- With continuous assessment during the semester, students will do assignments related to O1-O5.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Andrew P. McMahon, "Machine Learning Engineering with Python", Packt, 2021.
2. Valliappa Lakshmanan, Sara Robinson, Michael Munn, "Machine Learning Design Patterns", O'Reilly, 2020.
3. Mark Treveil et al. „Introducing MLOps", O'Reilly, 2020.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, "Practical Natural Language Processing", O'Reilly, 2022.
2. Valliappa Lakshmanan, Martin Görner, Ryan Gillard, "Practical Machine Learning for Computer Vision", O'Reilly, 2021.
3. Andriy Burkov Machine Learning Engineering, True Positive Inc., 2020.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

[23] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Associate Prof. Marina Ivašić-Kos, PhD	
Name of the course	**Soft Computing**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The aim of the course is to present the basic concepts and procedures of soft computing, which is based on the imitation of biological processes and models based on approximate calculation and inference, self-learning, parallelism and non-determinism.

1.2. Course enrolment requirements

There are no requirements for course enrollment.

1.3. Expected learning outcomes

It is expected that after successfully fulfilling the obligations in the course, the student will be able to:

O1. Critically judge and describe soft computing techniques and justify their role in the development of intelligent systems.
O2. Propose a solution to the problem of uncertainty by applying fuzzy logic models and techniques for representation and inference with fuzzy knowledge.
O3. Choose a suitable soft computing method and propose a solution concept in the context of given case studies.
O4. Choose appropriate methods and techniques of data analysis in order to prepare data for further processing
O5. Apply and tune neural networks to solve classification and regression problems.
O6. Recommend suitable soft computing methods for a self-defined problem and evaluate and connect them into a complete system and interpret the obtained results.

1.1. Course content

- Introduction to soft computing and neural networks: Evolution of computing. Fuzzy logic, neural networks and probabilistic inference.
- Fuzzy sets and fuzzy logic. Fuzzy rules.
- Fuzzy reasoning (fuzzy propositions, fuzzy relations and fuzzy implications).
- Fuzzy reasoning and decision-making systems.
- Introduction to evolutionary algorithms. Single-criteria and multi-criteria optimizations. Optimization problems.
- Genetic algorithms. Evolutionary operators (selection, mutation, recombination). Coding and decoding.
- Evolutionary algorithms for single-criteria optimization. Ant colony algorithm.
- Algorithms based on particle swarms for single-criteria optimization. Bee swarm algorithm.
- Evolutionary computing and multi-criteria optimization problems.
- Neural networks. Perceptron (Adaline). Multilayer perceptron (feedback learning).
- Learning paradigms. Optimization.
- Networks of radial basis functions. Fuzzy neural networks.

- Deep convolutional networks: layers, architectures, fine tuning, implementation details, applications.
- Deep recurrent neural networks.
- Deep probabilistic networks: Bayesian networks.
- Deep generative models.

1.2. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☒ mentorship ☐ other
1.3. Comments	The course combines independent work when adopting concepts and team and project work when solving specific problems.	

1.8. Student responsibilities

The student is expected to:

- regular attendance and participation in classes, and monitoring notifications related to classes in the e-learning system,
- access continuous knowledge checks (theoretical and practical colloquiums);
- design and create a practical project for the selected problem and data using neural networks or the soft computing method, and write a report and take the final exam where they will present the project and describe the experiment, evaluate and interpret the obtained results, and explain the selection of the best model (in the final exam, student should achieve at least 50% of points).

Detailed class activities and scoring will be specified in course syllabus.

1.9. Monitoring of student work[24]

Class attendance	2	Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	1
Project	1.5	Continuous assessment		Report		Practical work	
Portfolio						Report and presentation of results	0.5

1.10. Assessment of learning outcomes in class and at the final exam (procedure and examples)

• Practical test (colloquium on the computer) in which the student applies appropriate soft computing methods to the given problem and evaluates the obtained results (O2, O3)
• Practical test (colloquium on the computer) in which the student applies appropriate models of neural networks to the given data and evaluates the obtained results (O4, I5)
• A practical project task in which the student applies the theoretical foundations and knowledge of neural network models and soft computing techniques and creates a project according to predetermined instructions and evaluation criteria in which:

- designs a task that can be solved using neural network models and soft computing techniques, finds and prepares a set of learning data, chooses an appropriate method and examines different parameters to choose the model that gives the best result (O3, O4, O6).

[24] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- Creates a written report on the project and experimental work, which will contain an analysis of the problem, a description of the data set used, a description of the model and an explanation of the achieved results (O1, O3, O4, O6)
- The student will present the project and explain the obtained results (O1, O6)

1.11. Mandatory literature (at the time of submission of study programme proposal)

1. Kevin Murphy, Machine Learning: A Probabilistic Perspective, MITPress, 2012
2. H.J.Zimmermann: Fuzzy Set Theory and Its Applications, Kluwer Academic Publishers, 4th ed., 2001.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville (2016.), Deep Learning, MIT Press

1.12. Optional/additional literature (at the time of submission of the study programme proposal)

1. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007.
2. N. K. Sinha and M. M. Gupta, Soft Computing & Intelligent Systems: Theory & Applications-Academic Press /Elsevier. 2009.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2017; (online)
4. A. A. Eiben, J. E. Smith: Introduction to Evolutionary Computing. Springer, 2007.

1.13. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.14. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Full Prof. Patrizia Poščić, PhD	
Name of the course	**Business Communication and Communication Technologies**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire knowledge about communication, its verbal and non-verbal aspects, communication technology, digital tools and channels. Also, the goal is to develop the skills of effective communication and critical thinking in a business environment, as well as the creation of a digital personal portfolio that includes, among other things, a CV in several forms and a plan to develop one's own career in the IT profession.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Distinguish the basic concepts, methods and techniques of successful communication with an emphasis on contemporary trends in private and business communication.

O2. Apply verbal and non-verbal communication skills in practical, private and business situations, including situations of active listening, negotiation, leading and participating in business meetings, public speaking and non-violent conflict resolution.

O3. Apply the skills of business correspondence and creation of business documents (forms, requests, proposals, letters, recommendations, etc.) according to the rules of the profession and good practice.

O4. Create a CV in several forms (written, video, online) based on self-assessment of own abilities and ICT competences, plan for acquiring additional competences, plan for own career development and relevant international frameworks.

O5. Argument an opinion in written expression on a given topic, respecting the guidelines for the preparation of a professional paper, scientific paper or presentation and the rules of good practice.

O6. Recommend appropriate communication technologies, digital tools and channels for different business situations and application domains.

O7. Create your own communication program (for example, chatbot) for the selected business case.

1.4. Course content

- Basics of communication: Components and process of communication. Types of communication. Obstacles to successful communication. Cultural influences on communication.
- Verbal and non-verbal communication: a) Verbal: Language. Meaning. Clarity of expression. Formality of language. Differences in communication between men and women., b) Non-verbal: Types of non-verbal communication. Functions. Non-verbal expressiveness and sensitivity. Discrepancy between verbal and non-verbal communication. Self-presentation.
- Communication skills: a) Listening. The importance of listening. Components of listening. Techniques of active listening., b) Conflict and negotiation. Types of conflict. Causes of conflict. Consequences of

the conflict. Conflict resolution., c) Assertiveness. What is assertiveness? Causes of non-assertiveness. Specific techniques of assertive behavior., d) Public communication: Public speaking and presenting. The purpose of the speech. Characteristics of listeners. Organizing the speech. Speech presentation.

- Business communication: Communicating in the organization. Communication climate. Motivation, teamwork and communication in the team. Managing and leading meetings. Negotiation. Business correspondence. Public speaking. Creativity. Biography. Job interview.
- Guidelines for the design of professional/scientific work. Strategy for searching scientific databases and other sources.
- Contemporary trends and future in business communication: chatbots, podcast in business communication, hyper-personalized experience in business communication, etc.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. Students will be instructed to use the distance learning system immediately after enrolling into this course. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, creating CV, practical work) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[25]

Class attendance	2	Class participation	1	Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	1
Portfolio	1						

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assesment of the set of learning outcomes is done through class activities and/or forum discussions, creating CV, doing the practical work (project assignment) and creating a critical review:

- During class activities student applies verbal and non-verbal communication skills in practical, private and business situations (O2). For example, use body language to show a sense of concern.

[25] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- During forum discussion, student analyzes the basic concepts, methods and techniques of successful communication and makes a critical judgment about contemporary trends in private and business communication (O1) and recommends appropriate communication technologies, digital tools and channels for different business situations and domains of application (O6). For example, list the techniques of successful communication and recommend the appropriate communication technology for internal communication within the bank.
- When creating a portfolio, the student creates a CV in several forms (O4) and applies the skills of business correspondence and creation of business documents (O3) For example, create your own portfolio that includes a CV in several forms (written, video, online) and fill out a job application form, write an application, letter and motivation letter.
- On the final exam, student prepares a critical review of the given topic (O5). For example, write a critical review of scientific article X.
- Within the team project, student creates his own communication program for a selected business case (O7). For example, create a practical work on the topic "chatbot for the sale of mobile devices".

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Bovee, C. L., Thill, J.V. (2018). Business communication today. Pearson.
2. Buchberger, I. (2012). Kritičko mišljenje: priručnik kritičkog mišljenja, slušanja, čitanja i pisanja, Universitas, Rijeka.
3. Dwyer, J. (2020). The business communication handbook. Cengage.
4. Janarthanam, S. (2017). Hands-On Chatbots and Conversational UI Development: Build chatbots and voice user interfaces with Chatfuel, Dialogflow, Microsoft Bot Framework, Twilio, and Alexa Skills, Packt Publishing.
5. King, D. (2020). Effective Communication Skills: The Nine-Keys Guidebook for Developing the Art of Persuasion through Public Speaking, Social Intelligence, Verbal Dexterity, Charisma, and Eloquence. Blu Sal Digital Marketing Ltd.
6. Smith, J. M. (2021). Ultimate Guide To Business Writing: All The Secrets Of Creating And Managing Business Documents. Routledge / Taylor & Francis.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Cardon, P. (2020). Business Communication: Developing Leaders for a Networked World, McGraw-Hill Education.
2. Dalton, S. (2021). The Job Closer: Time-Saving Techniques for Acing Resumes, Interviews, Negotiations, and More. Clarkson Potter/Ten Speed
3. Guffey, M. E. (2019). Essentials of Business Communication, Cengage
4. Veis, C. A. (2017). Public Speaking for Engineers: Communicating Effectively with Clients, the Public, and Local Government. Clarkson Potter/Ten Speed.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Buchberger, I. (2012). Kritičko mišljenje: priručnik kritičkog mišljenja, slušanja, čitanja i pisanja, Universitas, Rijeka.	3	20
Janarthanam, S. (2017). Hands-On Chatbots and Conversational UI Development: Build chatbots and voice user interfaces with Chatfuel, Dialogflow, Microsoft Bot Framework, Twilio, and Alexa Skills, Packt Publishing.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously

evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assoc. Prof. Sanja Čandrlić, PhD	
Name of the course	**Information Systems Strategic Planning**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for BI module	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to acquire knowledge in the field of information systems strategic planning, which includes assessing the alignment of business processes with the organization's strategic goals, analysing priorities for business process improvement with the selection of an appropriate method for implementing the improvement, a plan for implementing the informatization of business processes, and evaluating scenarios for improving the business using ICT.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

It is expected that after completing all assignments prescribed in the course, students will be able to:

O1. Distinguish basic concepts, methods, techniques and approaches of the information systems strategic planning.

O2. Evaluate the alignment of business processes with the strategic goals of the organization and the level of agreed information services based on the analysis of approaches, methods and reference models of information systems and information technologies management.

O3. Justify the selection of an appropriate methodology for the implementation of a specific phase of the information lifecycle system and link it to a methodology suitable for the development of IS based on the analysis of the improvement priorities of the identified business processes.

O4. Create a proposal for business informatization in accordance with the organization's strategic goals, design methods for the recommended information services strategies and implementation plan for informatization of business companies.

O5. Integrate improved business processes into the business model, considering technological trends in ICT and their impact on business models.

O6. Evaluate business improvement scenarios using ICT and with regard to potential costs and effects based on a model of optimized business processes created using special software tools to implement the simulation model.

1.4. Course content

- Fundamentals of information systems. Organization. The role of IS and ICT in the organization. Information organization. Investment in IS/ICT. IS strategic plan. Overview of IS development methods. Approaches to IS development. Linking strategic business planning and IS strategic planning. Analysis of the current state of IS. Business processes. Information system architecture – determination of information subsystems.
- Development of information subsystems. Methods for determining the priority of computerization. Methods for harmonization of business needs of the company and its IS: business process reengineering, CSF method - Critical Success Factors. Cost-benefit analysis. SWOT analysis.

Outsourcing. Purpose of information system strategic planning. IS strategic planning process through phases: visioning, analysis, direction, recommendation.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in individual or team activities during lectures and exercises (activities in class/discussions on the forum, practical work, project activities, seminar paper) and achieve a number of points greater than or equal to the set threshold (if it exists).
- Take the final exam and score at least 50% on it.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[26]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous assessment	1	Report		Practical work	2
Portfolio		Homework	1				

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The assessment of the set of learning outcomes is done through continuous knowledge review, practical work and project assignment:

- In the written exam students demonstrate an understanding of the theoretical concepts, procedures, methods, and approaches of information systems strategic planning (O1). For example, they explain methods and techniques used during the phase of impact analysis of modern technology on the business system according to information systems strategic planning.
- The homework includes assessing the alignment of business processes with the organisation's strategic goals (O2) and analysing the improvement priorities of the identified business processes (O3).
- For example, analyse the organisation's mission, vision, and goals, or analyse informatization priorities considering the relevance of ICT to the processes.
- The practical work (final exam) includes the creation of a proposal and a plan for the implementation of business informatization of an organization (O4), the integration of business processes into the business model of the organization (O5) and the evaluation of the scenarios of business improvement,

[26] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

which includes the evaluation of potential costs and effects, and the creation of models of optimized business processes using special software tools for implementation simulation model (O6). For example: evaluate readiness of a company X for informatization of the procurement subsystem, create a proposal for thorough reorganization of its procurement subsystem taking into account the business organization model, and simulate the sales subsystem according to the model AS IS and TO BE.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Cassidy, A. (2006). A Practical Guide to Information Systems Strategic Planning. Auerbach Publications, Boca Raton, USA.
2. Dhillon, G.S. (2014). Strategic Information Systems Planning: Readings and Cases, Semantic Books.
3. Teubner, R. A., Stockhinger, J. (2020). Literature review: Understanding information systems strategy in the digital age. The Journal of Strategic Information Systems, 29(4).
4. Ward, J., Peppard, J. (2002). The Strategic Management of Information Systems: Building a Digital Strategy, 4th Edition. John Wiley&Sons.
5. Content prepared for learning through the learning system.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Brumec, J. (1998). Strategic Planning of Information Systems. Journal of Information and Organizational Sciences, vol. 2. Varaždin, Croatia.
2. Brumec, J., Dušak, V., Vrček N. (2001). Framework for strategic planning of information systems. Proceedings of the 7th Americas Conference on Information Systems. Boston, USA.
3. Clark, S. (2007). Information Systems Strategic Management: An Integrated Approach. RouthledgeSeries, Taylor and Francis.
4. Dobrović, Ž. (2000). Strategijsko planiranje, poslovna i informacijska arhitektura. Zbornik radova savjetovanja CASE 12, Opatija, Croatia.
5. Jonathan, G.M., Rusu, L., Van Grembergen, W. (2021). Business-IT Alignment and Digital Transformation: Setting a Research Agenda. Information Systems Development: Crossing Boundaries between Development and Operations (DevOps) in Information Systems (ISD2021 Proceedings). Valencia, Spain: Universitat Politècnica de València.
6. Ward, J., Peppard, J. (2002). Strategic planning fo Information Systems. John Wiley&Sons.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Cassidy, A. (2006). A Practical Guide to Information Systems Strategic Planning. Auerbach Publications, Boca Raton, USA.	1	20
Teubner, R. A., Stockhinger, J. (2020). Literature review: Understanding information systems strategy in the digital age. The Journal of Strategic Information Systems, 29(4).	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. Sanda Martinčić-Ipšić, PhD	
Name of the course	**Predictive Analytics**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory for IIS module	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The goal of the course is to develop business intelligence system based on predictive analytics.

1.2. Course enrolment requirements

Finished course: Data Mining

1.3. Expected learning outcomes

It is expected that upon successful completion of the obligations in this course, the student will be able to:

O1. Critically assess the importance and role of information to support business intelligence and the modern approach to business decision making based on predictive data analytics.
O2. Assess the specifics of business problem areas and recommend appropriate business and data intelligence methods and techniques.
O3. Design a management application for a data and business intelligence monitoring solution with the integration of complex reports and visualizations based on the integration of data from structured data sources (warehouses), semi-structured (NoSQL) and unstructured data (text, images, sensor data, etc.).
O4. Recommend a system architecture to solve a given business decision making problem based on methods of data analysis, statistics, in-depth data analysis, predictive analytics and principles of business intelligence.
O5. Prepare and integrate data from various structured and unstructured sources for the problem of predictive business analytics (transactional databases, files, social networks, texts, etc.).
O6. Construct a predictive model for a given business problem, e.g., segmenting customers, building a model for customer retention, monitoring and increasing customer satisfaction, reducing operational costs, predicting fraud and abuse, predicting and proposing a "customer basket" - market basket analysis," predicting trends in time data, analyzing and applying appropriate statistical methods and data mining to analyze and discover new business insights or knowledge.
O7. Evaluate and interpret predictive models using evaluation techniques.
O8. Design a system for business intelligence by applying business and data analytics methods and approaches, considering trends in data and business analytics.

1.4. Course content

- Introduction to business intelligence and modern approaches in business decision making based on data intelligence and predictive data analytics.
- Strategy for enterprise data management based on integration of heterogeneous sources. Data Quality.
- Dashboards to support business decision making based on data analytics.

- Processes for integrating data from heterogeneous sources: structured data sources (warehouses), semi-structured (NoSql, XML) and unstructured data (data lakes, large volume data, text, images, sensors, etc.).
- Visualization of information for business and data analytics.
- Predictive business analytics. Data preparation for business analytics.
- Construction and evaluation of predictive models using machine and statistical learning methods. Data Mining.
- Basic examples of business problems for predictive and business analytics: segmenting customers/users/products, predicting churn or retention of customers/users, analyzing business channels for sales and communications.
- Examples of business problems for predictive and business analytics: monitoring and increasing customer satisfaction, monitoring customer attitudes and opinions with special attention to text data and social networks.
- Examples of business problems for predictive and business analytics: cost reduction, prediction of fraud and misconduct, prediction and suggestions for analysis of the "customer basket" market basket analysis.
- Advanced examples of predicting trends in business time series data (stocks, financials, etc.).
- Practical examples from business practice - seminars and workshops in an industrial setting.
- Models for monetization of data.
- Legal and ethical aspects of data and predictive analytics.
- The future of business intelligence through the prism of upcoming trends in data analytics and data science, the evolution of Big Data and Data Analytics technologies, and trends in artificial intelligence especially in machine and deep learning.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	Instruction is delivered through a combination of face-to-face sessions (lectures and tutorials), individual assignments, and occasional industry-related seminars and workshops, as well as through the use of e-learning systems.	

1.7. Student responsibilities

The duties of students in this course are:

- Attending classes regularly, participating in all course activities, and following course notifications in the e-learning system.
- In addition, the practical application of the acquired knowledge includes the development and creation of a selected independent project work, that includes the construction of a business intelligence system with a control panel containing visualizations derived from the solved problem of predictive data for the selected business problem.
- The student is also required to complete assignments during the semester for continuous monitoring of student work, create and present an independent practical project work.
- The theoretical part of the course will be evaluated in the final exam with at least 50% of the points obtained.
- The detailed way of elaborating the course's grading and the passing thresholds for each assessment activity are specified in the detailed syllabus.

1.8. Monitoring of student work[27]

[27] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	***1***	Oral exam		Essay		Research	
Project		Continuous assessment	1	Report		Practical work	2
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- The theoretical portion of the course will be assessed in the final written or online exam, in which students must demonstrate their knowledge of business intelligence concepts by answering questions (e.g., multiple-choice questions, essay questions, solving a given problem or case), focusing on verification of O1, O2, and O8.
- Independent practical project work, which includes the preparation and creation of an independent practical project work that includes the construction of a business intelligence system with a dashboard containing visualizations derived from a solved predictive and data analytics problem for a selected business problem, will examine O3, O4, O5, and O6, where the student will demonstrate practical and theoretical application through dedicated project work and presentation of results.
- Through continuous monitoring throughout the semester, students will create independent assignments related to O1-O8.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Bernard Marr, Data Strategy: How to Profit from a World of Big Data, Analytics and Artificial Intelligence 2nd Edition, Kogan Page, 2022. https://bernardmarr.com/books/
2. John D. Kelleher, Brian Mac Namee and Aoife D'Arcy, Fundamentals of Machine Learning for Predictive Data Analytics Algorithms, Worked Examples, and Case Studies, 2nd Edition, MIT press, 2020. https://mitpress.mit.edu/books/fundamentals-machine-learning-predictive-data-analytics-second-edition
3. Wayne W. Eckerson, Performance Dashboards: Measuring, Monitoring, and Managing Your Business, 2nd Edition, John Wiley, 2011. https://www.wiley.com/en-us/Performance+Dashboards:+Measuring,+Monitoring,+and+Managing+Your+Business,+2nd+Edition-p-9780470589830
4. Edward Tufte, The Visual Display of Quantitative Information, Graphics press, 2001. https://www.edwardtufte.com/tufte/books_vdqi

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Claus O. Wilke, Fundamentals of Data Visualization, O'Riley, 2019. https://clauswilke.com/dataviz/
2. Alexander Loth, Visual Analytics with Tableau, Wiley, 2019. https://www.wiley.com/en-us/Visual+Analytics+with+Tableau-p-9781119560203
3. Cindi Howson, Successful Business Intelligence, 2nd Edition, McGraw- Hill, 2013. https://www.oreilly.com/library/view/successful-business-intelligence/9780071809184/
4. Hyndman, R.J., & Athanasopoulos, G. Forecasting: principles and practice, 3rd edition, OTexts: Melbourne, Australia. 2021. https://otexts.com/fpp3/
5. Foster Provost, Tom Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, O'Reilly Media, 2013. http://shop.oreilly.com/product/0636920028918.do
6. 6. Kuhn M, Johnson K, Applied predictive modeling, New York: Springer 2013. appliedpredictivemodeling.com/

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Bernard Marr, Data Strategy: How to Profit from a World of Big Data, Analytics and Artificial Intelligence 2nd Edition, Kogan Page, 2022. https://bernardmarr.com/books/ (17.2.2022.)	1	20
John D. Kelleher, Brian Mac Namee and Aoife D'Arcy, Fundamentals of Machine Learning for Predictive Data Analytics Algorithms, Worked Examples, and Case Studies, 2nd Edition, MIT press, 2020. https://mitpress.mit.edu/books/fundamentals-machine-learning-predictive-data-analytics-second-edition (17.2.2022.)	3	20
Wayne W. Eckerson, Performance Dashboards: Measuring, Monitoring, and Managing Your Business, 2nd Edition, John Wiley, 2011. https://www.wiley.com/en-us/Performance+Dashboards:+Measuring,+Monitoring,+and+Managing+Your+Business,+2nd+Edition-p-9780470589830 (17.2.2022.)	1	20
Edward Tufte, The Visual Display of Quantitative Information, Graphics press, 2001. https://www.edwardtufte.com/tufte/books_vdqi (17.2.2022.)	1	20
Bernard Marr, Data Strategy: How to Profit from a World of Big Data, Analytics and Artificial Intelligence 2nd Edition, Kogan Page, 2022. https://bernardmarr.com/books/ (17.2.2022.)	1	20
1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).		

General information		
Course instructor	Prof. Nataša Hoić-Božić, PhD	
Name of the course	**Virtual and Augmented Reality**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is the acquisition of basic knowledge and the development of skills necessary for analysing, planning, and creating applications for virtual/augmented reality. Students will be familiar with the concepts, principles, methods and techniques, as well as the appropriate hardware and software platforms for the production of virtual and augmented reality elements.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Distinguish the basic concepts of virtual reality and augmented reality and related concepts (mixed reality, extended reality, immersive user experiences).
O2. Evaluate existing virtual and augmented reality systems.
O3. Design immersive user experiences that use interaction appropriate for virtual/augmented reality hardware and platforms
O4. Shape the design, multimedia elements and programming scripts needed to effectively realize interactive and immersive virtual reality worlds.
O5. Create a virtual/augmented reality application prototype for the chosen platform based on the project development methodology.

1.4. Course content

- Virtual reality: fundamentals and definition, principles, historical development of virtual reality, input and output devices for virtual reality. Communication with the world of virtual reality, concepts and technologies of interaction.
- Augmented Reality: fundamentals and definition, characteristics, applications, image blending modes, augmented reality system mobility, AR hardware and software.
- Comparison: virtual, augmented, mixed reality.
- Immersive user experiences, 3D interaction approaches and technologies suitable for virtual/augmented reality hardware and platforms.
- Systems for virtual and augmented reality. Various applications of virtual and augmented reality in business, medicine, education, entertainment and other activities.
- Design and programming of virtual/augmented reality systems. Creating applications for virtual/augmented reality using project development methodology.

1.5. Manner of instruction

☒ lectures	☒ individual assignments
☐ seminars and workshops	☒ multimedia and network
☒ exercises	☐ laboratories
☒ distance learning	☐ mentorship

	☐ fieldwork	☐ other
1.6. Comments	The course is organised in blended form, which combines classroom work, individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Participate in continuous assessment activities (theoretical preliminary exams) and successfully complete them.
- Complete an individual or group assignment (seminar paper) on a given topic and present it to the course instructor and other students.
- Prepare a project, as the final exam. This activity requires the student to achieve at least 50% of the overall number of points for this activity.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[28]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment	1	Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written or online test (theoretical preliminary exam) in which students demonstrate their understanding of the basic theoretical concepts related to virtual reality and augmented reality (O1), and which may include recall type-tasks, multiple choice tasks, matching tasks, essay questions, and extended response items.
- Group assignment (using wiki or similar tool) in which students collaboratively analyse and evaluate virtual/augmented reality systems (O2). Students will receive in advance instructions for creating and criteria for evaluating the seminar.
- Group or individual practical project assignment (creating an application prototype) in a suitable virtual/augmented reality platform (e.g. Unity) on a selected topic from the fields of entertainment, education, business... prepared by students based on the project development methodology, taking into account the design, multimedia elements and interaction suitable for virtual/augmented worlds (O3, O4, O5).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Igor S. Pandžić, Tomislav Pejša, Krešimir Matković, Hrvoje Benko, Aleksandra Čereković, Maja Matijašević (2011.), Virtualna okruženja: Interaktivna 3D grafika i njene primjene, Element Zagreb, Manualia Universitatis Studiorum Zagrabiensis

[28] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

2. Benedikt Hensen i dr. (2020), The Open Augmented Reality Teaching Book, Dostupno online: https://codereality.net/ar-for-eu-book/ (17.2.2022.)
3. Prepared learning materials available through the system for distance learning

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Speicher, M., Hall, B., Nebeling. M. (2019), What is Mixed Reality?, In: CHI 2019, May 4–9, 2019, Glasgow, Scotland, UK
2. Augmented Reality and Virtual Reality: New Trends in Immersive Technology (2021), M. Claudia tom Dieck (Editor), Timothy H. Jung (Editor), Sandra M. C. Loureiro (Editor), Springer.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Benedikt Hensen i dr. (2020), The Open Augmented Reality Teaching Book, Dostupno online: https://codereality.net/ar-for-eu-book/ (17.2.2022.)	online	20
Igor S. Pandžić, Tomislav Pejša, Krešimir Matković, Hrvoje Benko, Aleksandra Čereković, Maja Matijašević (2011.), Virtualna okruženja: Interaktivna 3D grafika i njene primjene, Element Zagreb	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assist. Prof. Lucia Načinović Prskalo, PhD	
Name of the course	**Interactive Web Technologies**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to learn and apply various technologies and intelligent methods in interactive web applications, analyze patterns of user interaction with the web application, and integrate recommendation and personalization methods in web applications.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:
O1. Describe technologies and intelligent methods in interactive web applications.
O2. Recommend appropriate technologies for implementing interactive web applications.
O3. Evaluate appropriate technologies for developing components of interactive web applications.
O4. Analyze user interaction patterns with web application.
O5. Integrate recommendation and personalization methods into an interactive web application.
O6. Develop an interactive web application using elements of intelligent methods.

1.4. Course content

The course covers the following topics:

- Technologies and intelligent methods in interactive web applications. Use and application of intelligent methods. Incorporating intelligent methods into web applications.
- Web mining - extracting information from web documents and services, hyperlinks, and server logs; web usage mining - discovering user access patterns from web usage logs; mining the structure of the web - discovering useful knowledge from the structure of hyperlinks; web content mining - mining, extracting, and integrating useful data, information, and knowledge from the content of web pages.
- Analysing patterns of user behavior with the web application. Implementing various algorithms and procedures in analyzing patterns of user behaviour with the web application.
- Creation of suggestions and recommendations in web applications: concepts of distance and similarity, recommendations based on user similarity, item similarity and content similarity, implementation of recommender systems.
- Application of intelligent methods in the development of an interactive web application. Improving web applications and web sites by applying modern web technologies, such as intelligent design of web sites, localization, improved web personalization, improvement based on performance testing, etc.

1.5. Manner of instruction		
	☒ lectures	☒ individual assignments
	☐ seminars and workshops	☐ multimedia and network
	☒ exercises	☐ laboratories

	☒ distance learning ☐ fieldwork	☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regular participation in course activities within the e-learning system, in class in the form of lectures and auditory and/or laboratory exercises.
- Active participation in solving practical assignments in lectures and auditory and/or laboratory exercises or in the form of homework.
- Participation in and successful completion of continuous knowledge tests.
- As part of the final examination, a seminar paper on a given topic must be prepared and submitted to the course instructor. At least 50% of the points must be achieved in the final exam.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[29]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project	1.5	Continuous assessment	1	Report		Practical work	
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written or online knowledge tests that assess understanding of the theoretical concepts of intelligent methods in web applications, web mining, and recommendation and personalization methods in interactive web applications (O1, O4, O5).
- Practical assignments that assess the level of adoption of technologies for developing components of interactive web applications and integrating recommendation and personalization methods in web applications (O3, O4, O5).
- Project assignment (individual or group work) in which students create an interactive web application using elements of intelligent methods (O2, O4, O5, O6).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Douglas G. McIlwraith, Haralambos Marmanis, and Dmitry Babenko. (2016). *Algorithms of the Intelligent Web, Second, Edition*. Manning.
2. Bing Liu. (2013). *Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data (Data-Centric Systems and Applications), Second Edition*. Springer.
3. M. Russell and M. Klassen. (2018). *Mining the Social Web: Data Mining Facebook, Twitter, LinkedIn, Instagram, GitHub, and More, Third Edition*. O'Reilly.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Lawless W., Mittu R., Sofge D., Moskowitz I.S.S., and Russell, R. (2019). Artificial Intelligence for the Internet of Everything, First Edition. Elsevier.

[29] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

2. Lingras P., Akerkar R. (2010). *Building an Intelligent Web: Theory and Practice*. O'Reilly.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Bing Liu. (2013). Web Data Mining: Exploring Hyperlinks, Contents, and Usage Data (Data-Centric Systems and Applications), Second Edition. Springer	2	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assoc. Prof. Božidar Kovačić, PhD / Assist. Prof. Vanja Slavuj, PhD	
Name of the course	**Applied Learning Analytics**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The objective of the course is to enable students to widely apply digital technologies in the domain of educational processes, including the quality of data about the educational process, the selection and application of relevant data analysis tools, the interpretation of the obtained data (in view of the educational process), and the improvement of quality of decision-making during the educational process.

1.2. Course enrolment requirements

There are no enrolment requirements for this course.

1.3. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Determine the possibilities for improving the educational process for a given learning and teaching problem from practice.
O2. Transform the educational process in an e-learning environment by applying the selected digital technologies, aiming at improving the quality and efficiency of the educational process.
O3. Select, collect, and prepare educational data for automatic processing using appropriate tools and technologies.
O4. Analyse educational data that allow decision-making in educational systems, including the selection and argumentation of the chosen data analysis strategy.
O5. Implement a proposal for improving user experience with an e-learning system, grounded in the visualisation of the results of educational data analysis.
O6. Propose concrete changes and innovations related to the educational process, aimed at improving the performance of the educational institution and based on the evaluation of the analysed educational data.
O7. Apply the relevant norm, best practice example, or legal framework from the areas of security and privacy when handling sensitive user data.

1.4. Course content

The course includes the following topics:

- Adaptive e-learning systems and their application (business contexts, universities, MOOCs, testing organisations, etc.). Methods of system adaptivity – goals adaptivity, user modelling, data collection and organisation for content optimisation, content ordering, and adaptation of instruction methods and programmes.
- Techniques and procedures in learning analytics. Data types. Preparation of data for analysis. Structures discovery and predictive models.

- User-oriented learning analytics. Open user models. Adaptive visualisation based on user needs (dashboards). User development and progress. Participative design in learning analytics and inclusion of users in decision-making.
- Practical applications of learning analytics. Feedback and practice amendment. Decision-making and management strategies based on data.
- Ethical issues, privacy, and user data protection.

1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system. A detailed class schedule as well as lecture and exercise topics will be given in the course syllabus. Students will be instructed to use the distance learning system immediately after enrolling into this course.	

1.7. Student responsibilities

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures and auditory and/or laboratory exercises.
- Actively participate in practical problem-solving tasks during lectures and auditory and/or laboratory exercises.
- Participate in continuous assessment activities (theoretical preliminary exams) and successfully complete them.
- Complete a project assignment on a given topic, regularly document its development, and defend it (present it and answer questions) as part of the final exam. This activity requires the student to achieve at least 50% of the overall number of points for this activity.

A detailed scoring system for the course as well as passing scores for each activity will be given in the course syllabus.

1.8. Monitoring of student work[30]

Class attendance	2	Class participation	1	Seminar paper		Experimental work	
Written exam		Oral exam	0.5	Essay		Research	
Project		Continuous assessment	1	Report		Practical work	1.5
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Written test (theoretical preliminary exam) in which students demonstrate their understanding of the basic theoretical concepts related to learning analytics and the application of digital technologies in the transformation of an educational process, which may include recall type-tasks, multiple choice tasks, matching tasks, essay questions, and extended response items – O1, O2, O7.
- Practical homework assignments related to the application of digital technologies in the transformation of the educational process – O2, O3, O4.

[30] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- Practical project assignment related to the collection of educational data, preparation of such data for analysis, and interpretation of the results of the analysis in the light of decision-making concerning the educational process – O3, O4, O5, O6.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Khan, B. H., Corbeil, J. R., & Corbeil, M. E. (Eds.) (2019). *Responsible analytics and data mining in education*. Routledge.
2. Lodge, J. M., Horvath, J. C., & Corrin, L. (Eds.) (2019). *Learning analytics in the classroom: Translating learning analytics research for teachers*. Routledge.
3. Prepared learning materials available through the system for distance learning

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Liebowitz, J. (Ed.) (2021). *Online learning analytics*. Routledge.
2. Niemi, D., Pea, R. D., Saxberg, B., & Clark, R. E. (Eds.) (2018). *Learning analytics in education*. Information Age Publishing.
3. Sclater, N. (2017). *Learning analytics explained*. Routledge.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Responsible analytics and data mining in education.	1	20
Learning analytics in the classroom: Translating learning analytics research for teachers.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Associate Prof. Marina Ivašić-Kos, PhD	
Name of the course	**Computer Vision**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The main goal of this course is to familiarize students with the basic concepts and tasks of Computer Vision and with models and methods for working with image data and video.

1.2. Course enrolment requirements

There are no requirements for course enrollment.

1.3. Expected learning outcomes

It is expected that after successfully fulfilling the obligations in the course, the student will be able to:

O1. define the basic concepts and tasks of computer vision,

O2. explain and differentiate procedures, methods and algorithms related to image processing and feature extraction,

O3. compare the basic elements of neural network architecture and computer vision methods and explain their applicability for a given task in the field of computer vision,

O4. propose and apply appropriate computer vision methods for given problems such as image classification and object detection,

O5. evaluate the performance of the computer vision method on a given task and assess the quality of the solution,

O6. design and apply a suitable neural network model for a selected task in the field of computer vision.

1.4. Course content

- Introduction to Computer Vision. Definition.
- Goals and tasks of computer vision (classification and detection of objects, searching, describing images).
- Shaping and presentation of the image. Transformations, rotations, scaling of images.
- Extraction and feature representation. Color models, edges, interest points, blobs.
- Segmentation and segmentation methods.
- Classic computer vision systems; image classification.
- Basic architecture of a deep convolutional neural network. Activation functions. Filters. Defining network hyperparameters.
- Epochs, iterations, batch size. Optimization methods. Filter visualization.
- Data sets for learning and testing. Augmentation of data.
- Evaluation metrics; confusion matrix, loss, accuracy.
- An example of a simple deep convolutional network for the classification of handwritten characters. Learning methods.

- Adaptation and application of deep convolutional network for new tasks: image classification.
- Deep convolutional neural network models: case studies for image classification and object detection.
- Deep learning for image generation; generative models, unsupervised learning, case studies
- Deep learning for data sequences; case studies: video, audio, text
- Architecture design of a deep convolutional neural network for a given task: architecture selection, data loading and processing, model learning, result evaluation, model saving and use
- Using environments and services to define the architecture of a deep neural network and develop deep learning applications (Keras, Tensorflow, Colab).

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☒ laboratories ☒ mentorship ☐ other
1.6. Comments	The course combines independent work when adopting concepts and team and project work when solving specific problems.	

1.15. Student responsibilities

- The student is expected to attend classes regularly, create an experiment in the chosen field of computer vision, and write a report describing the experiment and explaining the results.
- Detailed class activities and scoring will be specified in course syllabus.

1.16. Monitoring of student work[31]

Class attendance	2	Class participation		Seminar paper		Experimental work	1
Written exam		Oral exam		Essay		Research	1
Project	1.5	Continuous assessment		Report		Practical work	
Portfolio						Report and presentation of results	0.5

1.17. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- The student will design a task in the field of computer vision and choose an appropriate neural network architecture. Different network parameters will be tested to select the ones that give the best result.
- The written report on the project and experimental work will contain an analysis of the problem, a description of the data set used, a description of the architecture used and an explanation of the results achieved.
- The student will present the project and explain the obtained results.

1.18. Mandatory literature (at the time of submission of study programme proposal)

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville: Deep Learning, The MIT Press, 2016. http://www.deeplearningbook.org/
2. Rajalingappaa Shanmugamani, Deep Learning for Computer Vision : Expert techniques to train advanced neural networks using TensorFlow and Keras, Packt Publishing Limited, 2018

1.19. Optional/additional literature (at the time of submission of the study programme proposal)

[31] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

1. Richard Szeliski, Computer Vision: Algorithms and Applications, September 3, Springer, 2010; http://szeliski.org/Book/

1.20. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.21. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Assoc. prof. M. Brkić Bakarić, PhD	
Name of the course	**Business Simulation**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION		
1.1. Course objectives		
The goal of the course is to introduce different aspects of complex system analysis by applying suitable simulation techniques.		
1.2. Course enrolment requirements		
There are no enrolment requirements for this course.		
1.3. Expected learning outcomes		
After fulfilling all the responsibilities prescribed by the course, students are expected to be able to: O1. Apply appropriate data collection techniques (define goal, identify relevant variables, choose appropriate research design). O2. Describe fundamental simulation principles and elements and identify problems that can be modelled and solved through simulation. O3. Design and implement a valid simulation model. O4. Identify method appropriate for a given problem. O5. Prepare input data (identify required input, generate random variables, conduct statistical analysis of input data). O6. Conduct a simulation study (define a problem, collect data, design a model, evaluate and assess model validity, implement a model, and analyse simulation results). O7. Compare different scenarios by running experiments. O8. Analyse simulation results with respect to decision making processes.		
1.4. Course content		
The course includes the following topics: • Data collection and summary. Simulation – basic concepts, areas of application, advantages and disadvantages. Models and modelling. Approaches to simulation modelling. Monte Carlo simulations. Modelling uncertainty. Discrete-event simulation. System dynamics. Agent-based simulation. Simulation software. Visualizing simulation results. Model testing and validation. Simulation games.		
1.5. Manner of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☒ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments	The course is organised in blended form, which combines auditory classroom work (lectures), computer laboratory work (exercises), individual work outside the classroom, and distance learning by using an e-learning system.	

1.7. Student responsibilities

- Student responsibilities for this course are to follow course activities within the distance learning system, attend classes, actively participate in practical problem-solving tasks, timely complete individual or group project assignments, participate in continuous assessment activities and achieve at least the number of scores defined by the given threshold, take the final exam and achieve at least 50% of the overall number of points for this activity.

A detailed scoring system for the course as well as thresholds (minimum score required) for each activity will be given in the course syllabus.

1.8. Monitoring of student work[32]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project	0.5	Continuous assessment	1	Report		Practical work	1.5
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Online quizzes in which students demonstrate their understanding of the basic simulation concepts, recognize the type of a given problem, and identify a method suitable for solving it (I2, I4), e.g., multiple choice tasks, cloze tasks.
- Assessment in the form of practical work (exercises, midterm exams, and final exam) includes designing and building different simulation models (I3, I5, I7, I8).
- A final exam in the form of a project assignment includes conducting a simulation study, comparing different scenarios, and presenting results (I1, I5, I6, I7, I8).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Duggan, Jim. System dynamics modeling with R. Vol. 501. Cham, Switzerland: Springer International Publishing, 2016.
2. Evans, James R. Business analytics. Pearson, 2017. (chapter 12)
3. Law, Averill M. Simulation modeling and analysis. 5th edition. New York: Mcgraw-hill, 2014.
4. Ott, R. Lyman, and Micheal T. Longnecker. An introduction to statistical methods and data analysis. Cengage Learning, 2015. (chapter 2)
5. Prepared learning materials available through the system for distance learning.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. Banks, Jerry. Discrete event system simulation. Pearson Education India, 2013.
2. García, Juan Martín. Theory and practical exercises of system dynamics: modeling and simulation with Vensim PLE. Preface John Sterman. Juan Martin Garcia, 2020.
3. Greasley, Andrew. Simulating business processes for descriptive, predictive, and prescriptive analytics. De Gruyter, 2019.
4. Kelton, W. David. Simulation with ARENA. McGraw-hill, 2002.
5. Robinson, Stewart. Simulation: the practice of model development and use. Bloomsbury Publishing, 2014. Morecroft, John DW. Strategic modelling and business dynamics: A feedback systems approach. John Wiley & Sons, 2015
6. Sterman, John. Business dynamics. McGraw-Hill, Inc., 2000.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

[32] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Title	*Number of copies*	*Number of students*
Duggan, Jim. System dynamics modeling with R. Vol. 501. Cham, Switzerland: Springer International Publishing, 2016.	1	20
Law, Averill M. Simulation modeling and analysis. 5th edition. New York: Mcgraw-hill, 2014.	1	20

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

General information		
Course instructor	Prof. Sanda Martinčić-Ipšić	
Name of the course	**Natural Language Processing Methods**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2.	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.1. Course objectives

The goal of the course is to apply machine learning and deep learning methods to unstructured text data and to solve standard tasks in natural language processing, such as: text classification, information retrieval of unstructured data, automatic document summarization, information extraction (e.g., entities and keywords), topic extraction from texts, monitoring opinions and sentiments, detection of toxic discourse or emotions from user comments, detection of fake news, development of dialog systems, text generation, semantic analysis, paraphrasing and natural language understanding, and other tasks.

1.2. Course enrolment requirements

Finished course: Machine and deep learning

1.3. Expected learning outcomes

It is expected that upon successful completion of the obligations in this course, the student will be able to:

O1. Evaluate and critically interpret principles, methods, and algorithms of computer-assisted text processing for solving standard natural language processing problems (tasks).

O2. Design and develop an appropriate machine and/or deep learning model in combination with classical NLP methods for a given natural language processing task.

O3. Evaluate machine and deep learning methods for the NLP task (problem).

O4. Asses the applicability of deep neural architecture or other deep structure to a given natural language processing problem in terms of available data, architectural constraints, and processing capacities.

O5. Assess the understandability of the obtained model in terms of evaluating the data scarcity and imbalance problem.

O6. Implement a natural language processing system for a specific problem (task).

O7. Design, plan, and prepare a text dataset from external unstructured sources and social networks for a specific problem (task) in practical application considering legal and ethical aspects.

1.4. Course content

- Problems of natural language processing, including the necessary statistical, linguistic, and computational foundations for developing methods of analyzing unstructured textual data.
- Corpus, preprocessing of text: stemming, lemmatization, stop words, tokenization. Linguistic resources.
- Introduction to deep learning for textual data. Logistic regression. Loss functions.

- Text representations: Sparse vector representation model (TF-IDF), bag-of-words model (BOW), dense representation models with low-dimensional vectors (embeddings). Continuous bag-of-words and skip-gram.
- Statistical language models. Neural language models.
- Information retrieval, similarity models, document retrieval and ranking. Semantic representation of words, sentences and texts. Semantic similarity. Evaluation methods.
- Methods of in-depth text analysis. Text classification. Text grouping. Principles of evaluation.
- Text classification tasks: Detection of opinions, sentiments, attitudes, emotions, toxic comments, fake news and others. Classification problems with a larger number of classes (multiclass) and labels (multilabel). Interpretation of the obtained models. Working with unbalanced classes.
- Deep learning models: deep feed-forward network. Recurrent neural networks. BiDirectional networks. Long-short-term memory cell (LSTM), Gated recurrent unit (GRU).
- Modelling of long sequences. POS (part od speech) tagging, entity recognition, etc.
- Attention mechanisms. Transformers. Learning according to principles of transferring tasks (transfer learning), principles of learning with one (one-shot learning) or several examples (few-shoots learning).
- Examples of problems/tasks: Information extraction. Keyword extraction. Extraction of relations. Principles of extraction evaluation. Extractive and abstract text summarization, text generation. Principles of evaluation of generated text. Dialog systems, chatbots and answering systems. Principles of evaluation.
- Automatic detection of topics in text. Latent representations of text. Principles of evaluation of latent models.
- Text coherence, resolution of co-references, paraphrasing. Determining and verifying the accuracy of facts.
- Semantics and language comprehension. Trends in natural language analysis and foundation language models (foundation models). Legal and ethical aspects.

1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments	Instruction is delivered through a combination of face-to-face sessions (lectures and tutorials), individual assignments, and occasional industry-related seminars and workshops, as well as through the use of e-learning systems.	

1.7. Student responsibilities

Students are expected to attend class regularly, participate in all course activities, and follow course notifications in the e-learning system. In addition, the practical application of the acquired knowledge includes the elaboration and creation of a selected project that involves the solution of some standard NLP tasks: Text classification, information retrieval in unstructured data, automatic document summarization, information extraction (e.g., entities and keywords), topic extraction, opinion mining, detection of toxic discourse or emotions from user comments, fake news detection, dialogue system development, text generation, semantic analysis, paraphrasing and natural language understanding, and other tasks. The student is also required to complete assignments throughout the semester (to continuously monitor student progress) and to create and present an independent practical project assignment. The theoretical part of the course will be evaluated in the final exam with at least 50% of the points obtained. The detailed way of elaborating the grading of the subject and the passing thresholds for each assessment activity are specified in the detailed syllabus of the subject.

1.8. Monitoring of student work[33]

Class attendance	2	Class participation		Seminar paper		Experimental work	
Written exam	1	Oral exam		Essay		Research	
Project		Continuous assessment	1	Report		Practical work	2
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- The theoretical part of the course will be reviewed in the final written or online exam, in which students will be asked to answer questions (e.g., multiple-choice questions, essay questions, solving a given problem/task or case), with an emphasis on checking O1-O5.
- Independent practical project work, work that involves solving one of the standard tasks of natural language processing (text classification, information retrieval in unstructured data, automatic document summarization, information extraction (e.g. entities and keywords), extraction of topics from texts, system development for monitoring opinions in comments, detection of toxic discourse or emotions from user comments, detection of fake news, development of dialogue systems, text generation, analysis of semantics, paraphrasing and understanding of natural language, etc.) O2-O7 will be examined, with the student demonstrating practical and theoretical application through dedicated hands-on work and presentation of results.
- Through continuous assessments throughout the semester, students will create independent assignments on O2-O6.

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Dan Jurafsky, James H. Martin, Speech and Language Processing, Prentice Hall (3rd edition), 2021.
2. Jacob Eisenstein, Introduction to Natural Language Processing, MIT Press, 2019. https://mitpress.mit.edu/books/introduction-natural-language-processing
3. Yoav Goldberg, Neural Network Methods in Natural Language Processing (Synthesis Lectures on Human Language Technologies), Morgan & Claypool Publishers, 2017.
4. C., Manning, H. Shütze: Foundations of Statistical Natural Language Processing, MIT Press, 1999.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. François Chollet, Deep Learning with Python, Manning Pub. 2017. https://www.manning.com/books/deep-learning-with-python
2. S. Bird, E. Klein, E. Loper: Natural Language Processing with Python, O'Riley, 2009. http://nltk.org/book/
3. Bing Liu, Web Data Mining, Springer, 2011. http://www.cs.uic.edu/~liub/WebMiningBook.html
4. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. http://nlp.stanford.edu/IR-book/information-retrieval-book.html

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Dan Jurafsky, James H. Martin, Speech and Language Processing, Prentice Hall (3rd edition), 2021. https://web.stanford.edu/~jurafsky/slp3/ (17.2.2022.)	online	20

[33] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

Yoav Goldberg, Neural Network Methods in Natural Language Processing (Synthesis Lectures on Human Language Technologies), Morgan & Claypool Publishers, 2017. https://www.morganclaypool.com/doi/10.2200/S00762ED1V01Y201703HLT037 (17.2.2022.)	2	20
C., Manning, H. Shütze: Foundations of Statistical Natural Language Processing, MIT Press, 1999. http://nlp.stanford.edu/fsnlp/ (17.2.2022.)	online	20
1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences		
Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).		

General information		
Course instructor	Prof. Ivo Ipšić, PhD	
Name of the course	**Man Machine Communication**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Elective	
Year of study	2.	
ECTS credits and manner of instruction	ECTS credits 6	
	Number of class hours (L+E+S)	

1. COURSE DESCRIPTION		
1.1. Course objectives		
Understand the principles of operation of systems for communication and interaction between users and computers.		
1.2. Course enrolment requirements		
none		
1.3. Expected learning outcomes		
O1. Explain the principles of operation of systems for communication and interaction between users and computers; O2. Use sample feature extraction procedures; O3. Use grouping and modeling process for pattern features; O4. Use sensory data classification procedures; O5. Propose the appropriate multi-modal interface for man-machine communication for the given scope and application scenario; O6. Develop a prototype human-machine communication system for the default application scenario; O7. Describe the areas of application of multimodal interfaces of human machine communication.		
1.4. Course content		
Introduction to the area of communication and interaction between users and computers. Specify the features of speech and image patterns. Language resources, corpuses, dictionaries, lexicons. Acoustic modeling of speech signals covered with Markov models and neural networks. Language modeling. Procedures for speech recognition. Semantic analysis of speech. Discovering lexical and sentence meaning. Speech dialogue systems. Dialogue modeling. Synthesis of speech. Multimodal and customizable interfaces. Identification-based input units (speech, gestures, handwriting, ...). Sensors as interface input units. Wearables. Assistive technology. Intelligent environments.		
1.5. Manner of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☐ mentorship ☐ other
1.6. Comments		
1.7. Student responsibilities		
Participation in teaching lessons, preparation of reports on the realized projects.		

1.8. Monitoring of student work[34]

Class attendance	2	Class participation		Seminar paper	1	Experimental work	1
Written exam		Oral exam		Essay		Research	
Project	1	Continuous assessment		Report		Practical work	1
Portfolio							

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

The evaluation of all learning outcomes shall be verified in the results achieved in individual or joint projects developed according to the preset instructions and criteria for evaluation. The project includes: elaboration of the selected topic and in the form of a written report with oral explanation, which will evaluate the outcomes of learnings O1, O5 and O7. related to understanding the principles of operation of the system for communication and interaction between users and computers. Creating a practical project task in which students need to create a prototype multimodal or customizable interface for communication and interaction between users and computers (O2, O3, O4, O6). Oral and written presentation of the results achieved on the project (O1, O5, O6, O7).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1. Huang, X. D., A. Acero and H. W. Hon (2000). Spoken Language Processing: A Guide to theory, Algorithm and System Development, Prentice Hall, New Jersey, USA.

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1. R. Szeliski: Computer Vision: Algorithms and Applications, 2nd ed. Springer 2022.

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*
Huang, X. D., A. Acero and H. W. Hon (2000). Spoken Language Processing: A Guide to theory, Algorithm and System Development, Prentice Hall, New Jersey, USA.	1	10

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course and their grade average).

[34] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

General information		
Course instructor	Prof. Nataša Hoić-Božić, PhD	
Name of the course	**Internship**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	6
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION		
1.1. Course objectives		
The objective of the course is for the student to apply the competencies acquired during the studies (knowledge, skills, independence and responsibility) in the real working environment of the holder of internship.		
1.2. Course enrolment requirements		
There are no enrolment requirements for this course.		
1.3. Expected learning outcomes		
After fulfilling all the responsibilities prescribed by the course, students are expected to be able to: O1. Responsibly apply acquired knowledge and skills for precise, thorough, and efficient solving of work tasks in a real environment. O2. Independently acquire the knowledge and skills necessary to successfully solve work tasks in a real environment. O3. Propose new ideas or tasks based on the analysis of practical problems. O4. Adapt to the business culture in a real work environment. O5. Critically evaluate the suitability of tools, techniques, and methods for solving work tasks in a real environment. O6. Act in accordance with instructions and feedback in the process of solving work tasks in a real environment. O7. Adapt to working in a team to solve work tasks in a real environment.		
1.4. Course content		
• The content of the work tasks will depend on the profile of the holder of internship (institution, company or other legal entity) where the student will perform internship.		
1.5. Manner of instruction	☐ lectures ☐ seminars and workshops ☐ exercises ☒ distance learning ☒ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☐ other
1.6. Comments		
1.7. Student responsibilities		
Student responsibilities for this course are to apply the acquired knowledge and skills to individual and team solving of work tasks in the real working environment of internship holders. The learning outcomes are evaluated by the mentor (appointed by the holder of internship) through the evaluation form for internship. The student is obliged to continuously keep a practice diary (e.g. in the form of an e-		

portfolio). In addition, the obligations of students are harmonized with the provisions of the Rulebook on Professional Practice of the Faculty of Informatics and Digital Technologies of the University of Rijeka.

1.8. Monitoring of student work[35]

Class attendance		Class participation		Seminar paper		Experimental work	
Written exam		Oral exam		Essay		Research	
Project		Continuous assessment		Report		Practical work	5
Portfolio	1						

1.9. Assessment of learning outcomes in class and at the final exam (procedure and examples)

In the context of solving work tasks, the following elements are evaluated: quality of the work tasks performed (precision, thoroughness, quantity and speed), the ability to learn (understanding and taking on new skills and ideas), the ability to take initiative (creating ideas and seeking new tasks and responsibilities), reliability, conscientiousness, punctuality, presence at work, acceptance of work tasks, acceptance of instructions and feedback, and engagement, ability to cooperate (effectively work with others, contribute to group activities).

1.10. Mandatory literature (at the time of submission of study programme proposal)

1.11. Optional/additional literature (at the time of submission of the study programme proposal)

1.12. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course).

[35] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

General information		
Course instructor	Mentors for students can be teachers in scientific-teaching and teaching titles.	
Name of the course	**Master's Thesis**	
Study programme	Graduate University Study Programme Informatics	
Status of the course	Compulsory	
Year of study	2nd	
ECTS credits and manner of instruction	ECTS credits	24
	Number of class hours (L+E+S)	30+30+0

1. COURSE DESCRIPTION

1.14. Course objectives

The purpose of the course is to introduce students to specific methodological issues related to the preparation of a thesis. The thesis is an independent professional work on a specified topic. With the thesis, the student must demonstrate the possession of competences and the achievement of learning outcomes in solving problems from professional and scientific areas that were the content of his/her studies, and the application of theoretical and practical knowledge acquired during his studies.

1.15. Course enrolment requirements

There are no enrolment requirements for this course.

1.16. Expected learning outcomes

After fulfilling all the responsibilities prescribed by the course, students are expected to be able to:

O1. Develop a strategy for searching scientific databases and other sources for finding relevant sources of scientific and professional information (print and digital collections) using library services and those available via the Internet.
O2. Review the reliability and quality of sources of professional and scientific information available via the Internet.
O3. Critically analyze the content of scientific or professional works.
O4. Argument an opinion in written and oral form.
O5. Apply guidelines for the design of professional papers and presentations.
O6. Demonstrate an understanding of concepts: plagiarism, self-plagiarism, citation, referencing, paraphrasing.
O7. Identify appropriate research methods or professional methods, techniques, and tools for solving a given problem or question that is interesting and relevant to the field of informatics.
O8. Recognize the need to independently acquire the knowledge and skills necessary to successfully solve the problem or question, based on a self-assessment of one's own competencies.
O9. Independently acquire the knowledge and skills necessary to successfully solve the problem.
O10. Plan activities and resources to solve the problem.
O11. Implement an activity plan to solve the problem.
O12. Analyze a given unstructured problem in the field of informatics and model its solution.
O13. Implement their own solution to the problem.
O14. Evaluate the solution to a given unstructured problem in the field of informatics.
O15. Organize the content of the presentation according to the concept, main ideas and scientific reasoning.
O16. Formulate scientifically reasoned answers to the questions.

1.17. Course content

- The subject of the course is the methodological and practical aspects of conducting thesis research, including topic selection, drafting, and final design.
- The research process is broken down, from prior research of the literature, selection of the topic, formulation of working hypotheses, work with the target literature and sources. The problem area of the work may be a specific information and communication system, which also requires work in practice.
- In particular, the practical aspects of creating an action and the methodological approach to algorithmic problem solving are elaborated. It also addresses the way sources are cited and scientific and professional works are analyzed. The organization of the work into chapters will be conceptualized, as will the choice of topic and the evaluation of the scientific nature/expertise of the work. Ethical aspects of research will be considered in the context of generally accepted principles of academic life, as expressed in ethical codes, and the anticipated societal implications of the topic under consideration. Special attention is given to issues of authorship.

1.18. Manner of instruction	☐ lectures ☐ seminars and workshops ☐ exercises ☒ distance learning ☐ fieldwork	☒ individual assignments ☐ multimedia and network ☐ laboratories ☒ mentorship ☒ other: consultations
1.19. Comments		

1.20. Student responsibilities

Students' responsibilities in this course are:

- Choose a mentor and the topic of the thesis and individually prepare the practical and technical part of the thesis through supervision and guidance.
- In addition, the course is harmonised with the provisions of the regulations of the Faculty which prescribes the students' obligations related to the preparation and defence of the thesis.

1.21. Monitoring of student work[36]

Class attendance		Class participation		Seminar paper	2	Experimental work	
Written exam		Oral exam	2	Essay		Research	18
Project		Continuous assessment		Report		Practical work	2
Portfolio							

1.22. Assessment of learning outcomes in class and at the final exam (procedure and examples)

- Learning outcomes are assessed through continuous supervision as part of the supervision, preparation, and public defense of the thesis.
- The final exam is the defense of the thesis in front of the defense committee and consists of an oral presentation of the results of the dissertation along with a prepared presentation and a knowledge test in the field of the thesis.

1.23. Mandatory literature (at the time of submission of study programme proposal)

1. Mejovšek, M. (2003.) Uvod u metode znanstvenog istraživanja u društvenim i humanističkim znanostima, Jastrebarsko : Naklada Slap ; Zagreb : Edukacijsko-rehabilitacijski fakultet.

[36] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

2. Vujević, M. (2003.) Uvod u znanstveni rad u području društvenih znanosti. Informator, Zagreb, 1990.
3. Skupina autora, Etički kodeks Sveučilišta u Rijeci. Sveučilište u Rijeci, Rijeka

1.24. Optional/additional literature (at the time of submission of the study programme proposal)

1.25. Number of assigned reading copies in relation to the number of students currently attending the course

Title	*Number of copies*	*Number of students*

1.26. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences

Periodical evaluations will be carried out in order to ensure and continuously improve the quality of the course and the study programme (as part of the activities of the Quality Assurance Committee of the Faculty of Informatics and Digital Technologies). In the last week of classes, students will anonymously evaluate the quality of the course. An analysis of student success in the course will also be carried out (percentage of students who successfully completed the course).