S V E U Č I L I Š T E U S P L I T U

FACULTY OF ELECTRICAL ENGINEERING, MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE

DETAILED PROPOSAL OF THE STUDY PROGRAMME

GRADUATE UNIVERSITY STUDY IN AUTOMATION AND SYSTEMS

SPLIT, May 2025

1.1. List ofmandatory and elective courses

List ofcourses								
Year of study:1.								
Semester:I.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
Mandatory	FEMG01	Modern physics	30	0	0	30	0	4
	FELK04	Computer graphics	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							
Elective	FELG32	Telemedicine and Biocybernetics	30	0	0	30	0	5
	FELH11	Artificial intelligence	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

List ofcourses								
Year of study:1.								
Semester:II.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
	FELG14	Operations research	30	0	0	30	0	5
	FELG10	Digital control	45	0	30	0	0	6
	FELG33	Optoelectronic measurement methods	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

List ofcourses								
Year of study:2.								
Semester:III.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
	FELG23	Optimization and optimal systems	30	0	30	0	0	5
	FELG24	Microcontrollers and network embedded systems	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

1.2. Course description

NAME OF THE COURSE	MODERN PHYSICS							
Code	FEMG01	Year of study	1.					
Course teacher	Nikola Godinović, Ph.D., Associate Professor	Credits (ECTS)	4					
Associate teachers	DunjaPolić, Darko Zarić, Toni Vrdoljak	Type of instruction (number of hours)	L	S	AE	LE	DE	
			30	0		30	0	
Status of the course	Obligatory	Percentage of application of e-learning	0					

COURSE DESCRIPTION

Course objectives	Understanding the basic laws and concepts ofquantumphysicsandtheirapplicationinmodernengineeringtechniques, technologyandinformation. Theacquiredknowledgeserves as a basis for theadoptionoffurtherexpertisethroughspecializedcourses, as well as preparing for theadoptionofprofessionalknowledgethroughouthiscareer.
Course enrolment requirements and entry competences required for the course	
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Developing ability of abstract thinking andu nderstanding the concepts of quantum physics on which modern technologies are based Understanding oftheel ectric and magnetic properties of the materials starting from their atomis structure Understandingthefenomenologyofsuperconductors. Basicunderstandingofnuclearphysicsandtheiraplication for energygeneration as well as basicunderstandingofradioactivityanddosimetry. Becomefamiliarwithmoderndiagnosticmethodsandtreatmentsinmedicne: nuclearmagneticresonance (NMR), positronemissiontomography (PET), Hadrontherapy, ...

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	LE hours
	Special theory of relativity	2	
	General theory of relativity	2	
	Particle properties of waves	2	
	Wave properties of particle	2	
	Introduction to wave mechanics - Schrodinger equation	2	
	Application of Schrodinger equation	2	
	Schrodinger equation for hydrogen atom	2	
	Electrical properties of material	2	
	Semiconductors	2	
	Magnetic properties of material	2	
	Phenomenology of superconductor	2	
	Atomic nuclei	2	
	Application of nuclear physics	2	

	List oflaboratoryor design exercises	LEhours
	Basics statistics of data analysis	4
	Light interference	2
	Measurement of the ratio of electron charge and mass	2
	Photoelectric effect	2
	Spectral line of gasses	2
	Solar cell characterisation	2

	Hall effect	2
	Semiconductor photo detectors	4
	Demonstrations of magnetism	2
	Demonstration of the phenomenology of superconductor	2
	Dosimetry	2
	Measurement of the gamma-rays spectrum	4

Format of instruction	☒**lectures** ☐seminars and workshops ☒**exercises** ☐*on line*in entirety ☐partial e-learning ☐ field work	☐independent assignments ☐multimedia ☒**laboratory** ☐work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	1,0	Research		Practical training	
	Experimental work		Report		Individual work	2,6
	Essay		Seminar essay		(Other)	
	Tests	0,2	Oral exam		(Other)	
	Written exam	0,2	Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterm exams, two final exams and one make-up exam. The first midterm exam is after 7 weeks of lectures and the second one is after the next 6 weeks. Each midterm test lasts for 90 minutes and consists of the following 4 questions: The requirement for passing grade at the midterm exams is to have at least 50% from each of 4 questions. Students that do not pass one of the midterm exams can retake it during the final exams. Final exams lasts 135 minutes each and consist out of the following 6 questions: The requirement for passing grade at the final exam is to have at 50% from each of 6 questions. Final grade is determined using the relative grading system based on the arithmetic mean of the per cents of each of the additional questions. Students that have passed both midterm exams or final exams are grouped in four categories: 15% of the students with the highest arithmetic means are assigned grade A (excellent), 35% of the students with the next best arithmetic means are assigned grade B (very good), 35% of the students with the next to next best arithmetic means are assigned grade C (good), and 15% of the students with the lowest passing arithmetic means are assigned grade D (satisfactory). Students who fail to pass the course through midterms and/or final exams have one make-up exam at the beginning of fall. This exam features the same format as the final exam. Exam schedule is predetermined through the academic calendar.

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• Knapp, V.; Colić, P.: Uvod u električna i magnetskasvojstvamaterijala, Školskaknjiga, Zagreb, 1997		
	• I. Supek, M. Furić: Počelafizike, Školskaknjiga, Zagreb, 1994.		
	• A. Beiser: Concepts of Modern Physics, sixth edition, McGraw-Hill 2003		

Optional literature (at the time of submission of study programme proposal)	• E.V. Wichmann: KvantnaFizika, udžbenikfizikeSveučilišta u Berkeley, svezak 4., Tehničkaknjiga, Zagreb, 1988. • D. Halliday, R. Resnick, J. Walker: Fundamentals of Physics 10th edition, John Wiley & Sons, Inc., 2013. • Vladimir Šips, Uvod u fizikučvrstogstanja, Školskaknjiga 2000.
Quality assurance methods that ensure the acquisition of exit competences	- Student evaluation surveys Teacher self-evaluation - Institutionalandnon-institutionalevaluations
Other (as the proposer wishes to add)	

NAME OF THE COURSE	**COMPUTER GRAPHICS**						
Code	FELK04	Year of study	1.				
Course teacher	Vladan Papić, Ph.D., FullProfessor	Credits (ECTS)	5				
Associate teachers	Denis Štajduhar, mag. ing.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding of basic principles and algorithms of computer graphics, - understanding of computer graphics technologies, - design and applications of computer graphics algorithms in C programming language and utilization of graphical libraries in programming..		
Course enrolment requirements and entry competences required for the course	None		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - explain graphical pipeline, - analyse basic algorithms of computer graphics, , - connect sequence of graphical transformations in order to achieve needed transformation for view, - recommend type of shading and animation in order to achieve desired result, - critical argue on possibilities and limitations of various display and hardcopy technologies, - model simpler objects with computer modelling software tools, , - create simpler animations with software tools, - create simpler computer programs for object presentation using graphical libraries.		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Uvod	2	
	Imageelements, vectorand raster systems, interactivegraphicsconcept	2	

	Basicalgorithmsofcomputergraphics	2	
	Primitivesfillingandclipping	2	
	Graphical hardware	4	
	Antialiasing	2	
	Geometrictransformations	2	
	Objectsin 3D space	2	
	Curvesandsurfaces	3	
	Lightningandshading	3	
	Animation	2	
	List of laboratory exercises		LE hours
	Introducton to OpenGL		4
	OpenGLexercise: Animation		2
	OpenGLexercise: Textures		2
	OpenGLexercise: Texturefilters		2
	OpenGLexercise: Ligthingandinteraction		2
	OpenGLexercise: Colorblending		2
	OpenGLexercise: 3D		4
	Blender: modelling		4
	Blender: animation		4

Format of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐*on line* in entirety ☐ partial e-learning ☐ field work	☒ independent assignments ☒ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	1,5	Research		Practical training	
	Experimental work		Report		Individual work	1,4
	Essay		Seminar essay	0,8	Laboratory exercises	0,5
	Tests	0,2	Oral exam		Preparation for laboratory exercises	0,5
	Written exam	0,1	Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. In the final exams students are answering parts they did not pass in the midterms. The midterm and final exams are carried out as written testsanditlasts for max. 60 minutes. The requirement for passing grade is 50% points on eachmidtermexamorfinalexam, writtenandaccepted seminar workandpositive assessment of laboratory exercises. In finalgrading (inpercentage), eachmidtermexamcontributeswithmax. 30%, seminar workwithmax. 30%, lab. exerciseswithmax. 10% outof total possiblepoints (30%+30%+30%+10%). Final grade isformedinthefollowingway: Percentage Grade 50% to 61% sufficient (2) 62% to 74% good (3) 75% to 87% verygood (4) 88% to 100% excellent (5)

Required literature (available in the	**Title**	**Number of copies in the library**	**Availability via other media**

library and via other media)	• T Papić, V.: Introduction to computergraphics, Facultytextbook, 2013. (in Croatian)		e-learning portal
Optional literature (at the time of submission of study programme proposal)	• J.D.Foley, A.Dam, S.K.Feiner, J.F.Hughes, Computer Graphics: PrinciplesandPractice (secondeditionin C), Addison-WesleyPublishing Company, 1996. • D.Hearn, M.P.Baker, Computer Graphics, C Version, Prentice Hall; 2nd edition, 1996. • F.S.Hill, Jr. i S.M. Kelley, Computer GraphicsUsingOpenGL, 3rd edition, Pearson education, 2007. • Shreiner, D., Woo, M., Neider, J., Davis, T., OpenGL vodič za programere, Kompjuter biblioteka, 2007.		
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations		
Other (as the proposer wishes to add)			

NAME OF THE COURSE	**TELEMEDICINE AND BIOCYBERNETICS**						
Code	FELG32	Year of study	1.				
Course teacher	Mojmil Cecić, Ph.D., Full Professor Josip Musić, Ph.D., Assistant Professor	Credits (ECTS)	5				
Associate teachers	Tea Marasović, Ph.D., Assistant Professor	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Elective	Percentage of application of e-learning	0				
COURSE DESCRIPTION							
Course objectives	Training students for: - understanding basic principles and techniques in the area of telemedicine and biocybernetics.						
Course enrolment requirements and entry competences required for the course	None						
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - explain computer and telecommunication basis for telemedicine. - evaluate properties of algorithms for image processing in telemedicine. - rate clinical application of telemedicine. - choose sources of medical information in light of distant learning paradigm. - evaluate systems for biomechanical human analysis. - analyze joint forces and moments in correlation with muscle activity. - experiment with measurement systems in biocybernetics based on EMG sensors, inertial sensors and optoelectronic sensors. - evaluate measurement results in light of possible future application and system limitations.						
	Course content						L

Course content broken down in detail by weekly class schedule (syllabus)		hours
	Introduction to telemedicine. Historical development of telemedicine.	2
	Computer and telecommunication basis for telemedicine.	2
	Equipment and services in telemedicine.	2
	Distant learning, searching through sources of medical information.	2
	Image processing in telemedicine.	2
	Ethics and telemedicine.	2
	Clinical application.	2
	Introduction to biocybernetics; overview of technical systems for measurement of human biomechanical parameters; measurement methods in biomechanics.	2
	Human anthropometric parameter identification; gait analysis: terminology and measurements.	2
	Gait parameter measurements; Kinematics and kinetics; Body position and balance during gate; measuring ground reaction forces during gait.	2
	Electromyography, measuring muscle activity during human movement.	2
	Inverse kinematics for muscle force identification.	2
	Machine vision in biocybernetics.	2

	List of laboratory or design exercises	LE hours
	Introductory lecture on laboratory safety procedures, laboratory measurement systems, and measurement procedures.	2
	Measuring human anthropometric parameters using finite element method.	3
	Measuring kinematic parameters during gait using fast cameras.	4
	Measuring ground reaction forces during gait using force plate.	3
	Measuring EMG muscle signals during gait.	4
	Calculation of muscle forces and moments during gait based on measured kinematical parameters and floor reaction forces. Comparison with recorded EMG signals.	4
	Measuring cervical spine range of motion using inertial motion sensors.	3
	Application of machine vision in classification and automatic translation of Croatian signed alphabet.	4
	Algorithms for image processing in telemedicine.	3

Format of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ *on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☒ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Student responsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	1	Research		Practical training	
	Experimental work		Report		Individual work	2
	Essay		Seminar essay		Laboratory exercises	1,5
	Tests	0,1	Oral exam		Preparation for laboratory exercises	0,3
	Written exam	0,1	Project		(Other)	

Grading and evaluating student work in class and at the final exam	During the semester there are two midterm exams. The first midterm exam is after 7 weeks of lectures (in the area of biocybernetics) and the second one is after 13 weeks of lectures (in the area of telemedicine in a form of a project assignment). Each midterm test (as well as the final test) is carried out in a written format with duration of 90 minutes. It consists of both theoretical questions and numerical problems. In the final exams students that did not pass the midterm exams take part. The final

<table>
<tr><td></td><td colspan="3">exam test consists of 8 theoretical questions and numerical problems. The requirement for passing grade is the positive assessment of laboratory exercises and 50 % points on average midterm exam ((M1 + M2)/2) or the final exam. Students are allowed to have at least 45% of total points on each midterm exams, as long as the final midterm average is at least 50% of total points.
Grade (in percentage) is formed according to the formula:

Grade(%) = 0,25L + 0,25M1 + 0,5M2

where:
• L – laboratory assessment,
• M1, M2 – midterm test results.

Final grade (based on percantages) is formed as follows:
Percentage Grade
50% do 62% sufficient (2)
63% do 74% good (3)
75% do 86% very good (4)
87% do 100% excellent (5)

According to Article 65. of Faculty’s Bylaw, student is required to participate in all teaching activities attending at least 70% of lectures, and 100% of laboratory exercises. In accordance with that student is required to solve and turn over for grading 100% of all laboratory exercises. If student does not meet these criteria, she or he won’t be able to take part in the final exam, and will be required to enroll in the course the next year.</td></tr>
<tr><td rowspan="5">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>• I. Klapan, I. Čikeš:; Telemedicina u Hrvatskoj, Medika, Zagreb, 2001.</td><td>3</td><td>teacher</td></tr>
<tr><td>• R. J. Jagacinski, J. M. Flach: Control Theory for Humans: Quantitative Approaches to Modeling Performance, Lawrence Erlbaum Associates Inc., 2003</td><td></td><td>teacher</td></tr>
<tr><td>• T. Marasović, Guidelines for laboratory exercises, FESB</td><td></td><td>e-learning portal</td></tr>
<tr><td>• M. Cecić, J. Musić: Authorized lecture notes, FESB</td><td></td><td>e-learning portal</td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">1. Winter D.A.: The Biomechanics and Motor Control of Human Gait, University of Waterloo Press, Waterloo, 1991.
2. Zanchi V., Cecić M., Grujić T., Kuzmanić A., Papić V. : Laboratory for Identification of Human Movement with LaBACS Software Support, International Congress on Computational Bioengineering, ICCB’03, 24-26 September 2003., Zaragoza, Spain, p.p. 155-161
3.I. Kaplan, I Čikeš (editors): “Telemedicine“, Telemedicine Association, Zagreb, 2005.
4. V. Štambuk: “Kibernetika s informatikom”, 1989.
5. V. R. Milačić : “Tehnička kibernetika”, 1981.
6. N. Wiener: “Kibernetika ili upravljanje i komunikacija kod živih bića i mašina”, 1972.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Keeping records of student attendance
- Annual analysis of course statistics in terms of midterm and finals exams
- Feedback from students via surveys
- teacher self evaluation
- Feedback from graduated students (or senior students) on course content relevance</td></tr>
</table>

	- Periodic institutional evolution of course teachers
Other (as the proposer wishes to add)	/

NAME OF THE COURSE	**ARTIFICIAL INTELLIGENCE**						
Code	FELH11	Year of study	1				
Course teacher	Darko Stipaničev, Ph.D., Full Professor (60%) Ljiljana Šerić, Ph.D., Assistant Professor (40%)	Credits (ECTS)	5				
Associate teachers	Toni Jakovčević, Ph.D., Assistant Professor	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Elective	Percentage of application of e-learning	80				
COURSE DESCRIPTION							
Course objectives	The aim of the course is to teach students basic knowledge in the field of artificial intelligence, ways of collecting and storing knowledge, to methods and algorithms by which this knowledge is used in solving complex tasks. In addition to an introduction to the theoretical foundations of artificial intelligence and illustrate the many applications in science and economy.						
Course enrolment requirements and entry competences required for the course	Basic knowledge of computers and programming. To follow the College is necessary knowledge of English.						
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to successfully mastering the subject: 1. Explain the differences between biological intelligence, artificial intelligence, computational intelligence and distributed intelligence. 2. Present complex tasks and prepare them for automatic solving them. 3. Understand the difference between data, information and knowledge and systems based on knowledge. 4. Explain the procedures of knowledge elicitation and knowledge storing using different types of mathematical logic (propositional logic, predicate logic, non-standard logic). 5. Apply the structural representation of knowledge, particularly semantic networks, frames, scenarios, stereotypes, and production rules. 6. Describe and present standard methods of solving tasks of artificial intelligence, especially methods of searching the knowledge base (undirected and directed search) 7. Apply logical reasoning, probabilistic reasoning, fuzzy reasoning 8. Apply simple machine learning tasks (unsupervised and supervised). 9. Write simple programs in programming languages and tools of artificial intelligence (Prolog, LISP, AIXML, Jess). 10. Describe the application of artificial intelligence, in particular through expert systems.						

<table>
<tr><td rowspan="11">Course content broken down in detail by weekly class schedule (syllabus)</td><td>Course content</td><td>L or S hours</td><td>LE hours</td></tr>
<tr><td>Introduction to Artificial Intelligence - the name, history, related disciplines. Biological intelligence, the theory of multiple intelligences. The research area of artificial intelligence. The techniques of artificial intelligence and success criteria.</td><td>4</td><td>0</td></tr>
<tr><td>Complex tasks and their preparation for solving using AI methods. Problem solving techniques using search (undirected and directed search)</td><td>4</td><td>0</td></tr>
<tr><td>Knowledge and storage of knowledge – I part introduction, data, information, knowledge. Knowledge-based systems. Knowledge and storage of knowledge - II part mathematical logic (standard and non-standard logic).</td><td>4</td><td>0</td></tr>
<tr><td>Logical reasoning. Probabilistic reasoning (probability, conditional probability, Bays networks, hidden Markov models). Fuzzy (fuzzy) reasoning.</td><td>6</td><td>0</td></tr>
<tr><td>Knowledge and storage of knowledge - Part III structure storage knowledge (semantic networks, stereotypes, the script, frames, production systems).</td><td>2</td><td>0</td></tr>
<tr><td>Machine learning (unsupervised and supervised)</td><td>4</td><td>0</td></tr>
<tr><td>Examples of applications of artificial intelligence. Expert systems. Processing and understanding speech. Computer vision.</td><td>2</td><td>8</td></tr>
<tr><td>The programming language LISP</td><td>0</td><td>15</td></tr>
<tr><td>The programming language Prolog and expert system shell</td><td>0</td><td>15</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Format of instruction</td><td colspan="3">☒ ☒ lectures
☐ ☒ seminars and workshops
☒ ☒ exercises ☐ on line in entirety
☐ partial e-learning
☐ field work
☐ independent assignments
☒ multimedia
☒ ☒ laboratory
☐ work with mentor
☐ (other)</td></tr>
<tr><td>Student responsibilities</td><td colspan="3">The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.</td></tr>
<tr><td>Screening student work (name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)</td><td colspan="3"><table>
<tr><td>Class attendance</td><td>1,5</td><td>Research</td><td></td><td>Practical training</td><td></td></tr>
<tr><td>Experimental work</td><td></td><td>Report</td><td></td><td>Individual work</td><td></td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td></td><td>Laboratory exercises</td><td>1,5</td></tr>
<tr><td>Tests</td><td></td><td>Oral exam</td><td></td><td>Preparation for laboratory exercises</td><td></td></tr>
<tr><td>Written exam</td><td>2</td><td>Project</td><td></td><td>(Other)</td><td></td></tr>
</table></td></tr>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="3">The exam consists of a written part and if necessary additional oral exam. During the semester will be two tests. The first colloquium in 8 weeks of classes, the second at 18 weeks. A student can pass the course by these tests. In the two final exams in June and July, students who have not collected inadequate number of points through colloquia take the whole subject covered by the two tests. The condition for taking the final exam is successfully finished practical lab exercises.

The exam is comprehensive and includes the theoretical part of the material and tasks with auditory exercises. The condition for positive assessment is that the student has a total of at least 50% on the exam or when it must have a minimum 25% passing the theoretical part of the material and 25% of the deposited duties. If a student has less than 25% of the points on the tasks and / or less than 25% points from the theoretical part of the material again taken the entire exam.</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">Students who did not pass the exam after two final exams can pass the exam in autumn periods. All test questions students will be known before the exam.

These rules apply equally to students who are enrolled this course for the first time and to those students who enter college for the second time.

The final grade is determined as follows:
percentage Rating
50% to 61% is sufficient (2)
62% to 74% good (3)
75% to 87% of very good (4)
88% 100% Excellent (5)

The first colloquium will take the material to the teaching units to the seventh week inclusive, and on the other the rest of the teaching weeks. Examinations are held in terms of the anticipated calendar of classes.

Under Article 65 of the Statute of the Faculty, the student is required to participate in all forms of teaching and attend: lectures at least 70% of classes. If she or he do not meet these requirements, the student will not be able to take the exam and get a signature.</td></tr>
<tr><td rowspan="6">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the</td><td>Availability via other media</td></tr>
<tr><td>D.Stipaničev, Lj. Seric, Lectures from artificial intelligence, lecturing notes and internal textbook</td><td></td><td>e-learning portal</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">- A.Cawsey, The Essence of Artificial Intelligence, Prentice Hall, 1998.
- S.Russel, P.Norvig, Artificial Intelligence: A Modern Approach, Prentice Hall, 2nd Ed. 2002.
- AI on the Web (http://http.cs.berkeley.edu/%7Erussell/ai.html)
- American Association for Artificial Intelligence (www.aaai.org)</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Evaluation of results in accordance with the above learning outcomes
- Feedback from students via surveys
- Self-evaluation of teachers
- Institutional and non-institutional evaluations</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
</table>

NAME OF THE COURSE	OPERATIONS RESEARCH						
Code	FELG14	Year of study	1.				
Course teacher	Jadranka Marasović, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Martina Bašić, mag.img.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Elective	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: To enable students using examples to understand the importance of optimimal solutions for engineering practice and research. By gaining knowledge through basic concepts of optimization, the necessary theoretical knowledge about different approaches can be achieved, about mathematical and heuristic methods, about the fastest and organized search for optimal solutions, too. To enable students to acquire practical knowledge, user-oriented, on the need for software solutions and precision interface in order to work independently to obtain optimal solutions. Examples from everyday life are used.
Course enrolment requirements and entry competences required for the course	None
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: 1. iimplement models of different systems, quantitative (math) and qualitative (graphs, tables, text) models, 2. apply mathematical conversion to the original models and to understand the purpose of these conversions in the application of known methods of optimization, if the solutions and methods for the original model do not exist, 3. describe the difference between defined mathematical optimization methods and search methods and describe the impossibility of finding a universal method of solving, 4. pick and sort out the proper method of optimization based on model, 5. apply the results optimum analysis on the appropriate practices, 6. calculate the strategic optimum, 7. solve independently complex tasks of optimizing where it is necessary to combine several methods.

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction: Systems approach and purpose and power of modeling (in the analysis and understanding of systems acting and in the problems with the synthesis of the "living" systems). The model is an approximation of the system. Modeling is an iterative process during which resolves a compromise between complex models and quality of approximation.	2	0
	Quantitative models and diffferences of the systems characteristics: deterministic, stochastic, static, dynamic, continuous, discrete, linear and nonlinear. The selection of input and output variables and their impact on the complexity of the model. Physical, economic and other laws as a basis for building models. Qualitative models.	2	0
	The impact of constraints on the behavior of the system and how to add them to the original model - space of solutions. Objective function as an indicator of optimality. Optimal is not perfect - depends on objective function,on constraints and on methods of solving. Multidisciplinary approach as the main feature of all tasks optimization.	2	0

	Operations research, history and way of thinking with the tasks of optimization. Mathematical conversions and mathematical operations - basic ideas used through the orientation in space of solutions and seeking optimum.	2	0
	Linear static models. The standardization of models. Problems with unbounded spaces solutions (infinite limits).	2	0
	Simplex algorithm - one of 10 the best algorithms of the 20th century. Examples of solving. The meaning of optimality criteria and feasibility criteria.	2	0
	Qualitative models - poorly structured models. Heuristics. Search. Branching (Branch and Bound method).	2	0
	Transport problem. Methods seeking basic possible solutions and methods of seeking improved solution to the optimum - the basics of search.	2	0
	Transport problems with ambiguous warehouses (transshipment problem)	2	0
	0-1 Programming. Backpack problem (loading / unloading). Travelling salesperson.	2	0
	Game theory and optimal strategic decisions-making.	2	0
	Nonlinear Programming: mathematical procedures that can create problems to resolve and seek optimum. It is essential to create characteristic search, which can become complicated, but can unexpectedly diverge. Basic information are what, why and how to keep it under control.	2	0
	Graph theory. Modeling events and activities. Optimization tasks modeled using graph theory (CPM method - Critical Path Method). Software solutions such tasks.	2	0
	List of laboratory or design exercises		LE hours
	Postoptimal analysis, the reasons for its implementation to the optimal results from the practice.		2
	Sensitivity analysis of optimal solutions depending on the change of the coefficients of the objective function. Examples.		2
	Sensitivity analysis of optimal solutions depending on the change of the coefficient from the right side of constraints. Examples.		2
	Preparing for use of already created software solutions with examples of linear programming, data for software: input and output		2
	Integer programming: the need and ways to search for such solutions in linear programming. Examples.		2
	A simple example of solving linear programming tasks - solving using already created software on a digital computer and "hand-made mathematical solutions".		2
	Testing problems of parameters sensitivity, solving tasks using already created software on a digital computer and "hand-made mathematical solutions".		2
	Solving simple example of dual Simplex, using digital computer and graphics solutions.		2
	The application of the dual simplex in practice with the example of optimal cutting shape, minimization of material thrown. The use of linear programming tasks in automation systems.		2
	Solving examples of optimal transport of goods between several towns in Croatia - the basic transport problem.		2
	Solving examples of optimal transport of goods between several cities in Croatia - ambiguous warehouses.		2
	Illustration "the power of models" in the example of problem-solving scheduling (students - classrooms). The problem layout, basically 0-1 programming can be mathematically translated into a form of transport problems and dealt with using "its" program.		2
	Problem solving traveling salesman, optimal touring several cities in Croatia.		2

<table>
<tr><td>Format of instruction</td><td colspan="6">☒ lectures
☐seminars and workshops
☐ exercises
☐on line in entirety
☐partial e-learning
☐field work

☒ independent assignments
☐ multimedia
☒ laboratory
☐work with mentor
☒ seminar essay (other)</td></tr>
<tr><td>Student responsibilities</td><td colspan="6">Minimum of 70 percent lecture attendance. Completing all the required laboratory exercises.</td></tr>
<tr><td rowspan="6">Screening student work (name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)</td><td>Class attendance</td><td>1.5</td><td>Research</td><td></td><td>Practical training</td><td></td></tr>
<tr><td>Experimental work</td><td></td><td>Report</td><td></td><td>Individual work</td><td>0.5</td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td>1</td><td>Laboratory exercises</td><td>1</td></tr>
<tr><td>Tests</td><td>0.5</td><td>Oral exam</td><td></td><td>(Other)</td><td></td></tr>
<tr><td>Written exam</td><td>0.5</td><td>Project</td><td></td><td>(Other)</td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="6">During the semester there will be two mid-term exams (tests). The first mid-term will be held during class (according to the calendar), and the other colloquium after the end of classes. Individual colloquium will be considered passed if it achieved 40% correct answers, or total points achieved that give a positive evaluation must be at least 50% correct.
It is necessary during the semester to resolve homework and seminars to be recognized (enrolled) score achieved by tests and exams.
The final grade is determined based on the total number of points earned, which is calculated as follows (Including laboratory exercises points, M3)
Grade [%] = 0.45 * M1 + 0.45*M2 + 0,1*M3
Percentage Grade
50% to 61% sufficient (2)
62% to 74% good (3)
75% to 87% very good (4)
88% to 100% excellent (5)
The final exam encompasses the entire course load or selected parts of it that students' did not pass at either of mid-term exams. The correction exam encompasses the entire course load. The requirement for passing the exam is minimum of 50 percent correct answers. The exams are held according to the class schedule.</td></tr>
<tr><td rowspan="2">Required literature (available in the library and via other media)</td><td colspan="3">Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td colspan="3">J.Marasović: “Introduction in Operations Research“ (in Croatian: Uvod u operacijska istraživanja, Authorized lectures, FESB, 2000.</td><td></td><td>e-learning portal</td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="6">- T.B. Boffey: “Graph Theory in Operations Research”, McMillan Press, Hong Kong, 1982.
- R. Bronson, G. Naadimuthu: “Operations Research”, Schaum’s Outline of Operations Research, McGraw Hill, 1998.
- H.A. Taha: “Operations Research: An Introduction”, Prentice Hall, 1997</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="6">- Keeping records on class attendance
- Annual analysis of exam results
- Student survey on teaching performance
- Teacher self-evaluation
- Feedback information from graduates regarding course content relevancy</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="6"></td></tr>
</table>

NAME OF THE COURSE	DIGITAL CONTROL							
Code	FELG10	Year of study	1					
Course teacher	Darko Stipaničev, Ph.D., Full Professor	Credits (ECTS)	6					
Associate teachers	Josip Musić, Ph.D., Assitant Professor	Type of instruction (number of hours)	L	S	AE	LE	DE	
			45	0	30	0	0	
Status of the course	Obligatory	Percentage of application of e-learning	80					

COURSE DESCRIPTION

Course objectives	The acquisition of advance knowledge about the processes of analysis and design of digital control.		
Course enrolment requirements and entry competences required for the course	Completed course Linear control systems.		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to successfully mastering the subject: 1. Describe the historical development of digital management 2. Identify the difference between continuous and discrete signals and systems. 3. Explain quantisation of continuous signal by time, sampling, A / D converter. 4. Apply techniques for restoring continuous signal from discrete signals, 0-order holder, D / A converter. 5. To model discrete systems using equations difference. Z-transformation. Modified-Z transform. Impulse transfer functions. The equivalent system. 6. Know how to identify impulse transfer function. 7. Describe the discrete by system state variables. 8. Analyse discrete system as follows: Stability. Analysis of transient response. Accuracy and error steady state. 9. Analyse discrete system in the frequency domain, in complex areas (root locus of discrete system), and analyse discrete system by state variables. 10. Apply various discrete control systems design procedures: Sampling of the continuous controller. Design of discrete controllers based on continuous data (setup poles and zeros, the procedure based on the definition of the desired response). The design of discrete controllers in the pseudo-frequency domain. State feedback design principles. 11. Establish and implement digital control through realization of impulse transfer function of a discrete controller. 12. Recognise potential problems of implementation of digital control (scaling, quantization noise). 13. Understand hoe digital control could be applied.		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L or S hours	AE hours
	Introduction to digital control, continuous and discrete signals and systems, sampling and recovery, A / D and D / A	6	0
	Modeling of discrete systems - difference equations, Z transform, modified Z transform	3	8
	Impulse transfer function and equivalent impulse transfer function. Parameter identification of equivalent impulse transfer function	6	2
	Description of discrete systems by state variables	3	2
	Analysis of discrete control systems in the time domain - transients. Analysis of discrete control systems in complex domain. Analysis of discrete control systems in pseudo-frequency domain. Analysis of discrete control systems in state space domain.	6	6
	Design of discrete controllers - discretization of continuous controllers. Discrete PID controller	3	2

	Discrete controller design by continous data (Dahlin and Kalman method)	6	2
	Discrete controller design in state space domain	3	2
	Realization of implementation of digital control systems.	3	2

Format of instruction	☒ ☒ lectures ☐ seminars and workshops ☒ ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☒ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Student responsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2,5	Research		Practical training	
	Experimental work		Report		Individual work	
	Essay		Seminar essay		Laboratory exercises	
	Tests		Oral exam		Preparation for laboratory exercises	
	Written exam	**3,5**	Project		(Other)	

Grading and evaluating student work in class and at the final exam	The exam consists of a written part and if necessary additional oral exam. During the semester will be two tests. The first colloquium in 8 weeks of classes, the second at 18 weeks. A student can pass the course by these tests. In the two final exams in June and July, students who have not collected inadequate number of points through colloquia take the whole subject covered by the two tests. The condition for taking the final exam is successfully finished practical lab exercises. The exam is comprehensive and includes the theoretical part of the material and tasks with auditory exercises. The condition for positive assessment is that the student has a total of at least 50% on the exam or when it must have a minimum 25% passing the theoretical part of the material and 25% of the deposited duties. If a student has less than 25% of the points on the tasks and / or less than 25% points from the theoretical part of the material again taken the entire exam. Students who did not pass the exam after two final exams can pass the exam in autumn periods. All test questions students will be known before the exam. These rules apply equally to students who are enrolled this course for the first time and to those students who enter college for the second time. The final grade is determined as follows: percentage Rating 50% to 61% is sufficient (2) 62% to 74% good (3) 75% to 87% of very good (4) 88% 100% Excellent (5) The first colloquium will take the material to the teaching units to the seventh week inclusive, and on the other the rest of the teaching weeks. Examinations are held in terms of the anticipated calendar of classes. Under Article 65 of the Statute of the Faculty, the student is required to participate in all forms of teaching and attend: lectures at least 70% of classes. If she or he do not meet these requirements, the student will not be able to take the exam and get a signature.

	Title	**Number of copies in the**	**Availability via other media**

Required literature (available in the library and via other media)	D.Stipaničev, J.Marasović, Digitalno vođenje on-line, on-line (Web) udžbenik, MZT – Informatički projekt, 2004. http://laris.fesb.hr/digitalno_vodjenje		e-learning portal
Optional literature (at the time of submission of study programme proposal)	• Aström, K.J.; Wittenmark, B.Computer controlled systems - theory and design, Prentice-Hall Int. series, London, 1996. • J.R.Vaccaro, Digital Control – A State Space Approach, McGrawHill, 1995. • J.A.Borrie, Modern Control Systems – A Manual of Design Methods, Prentice Hall Int., 2000 • D.Ibrahim, Microcontroller Based Applied Digital Control, J.Willey & S.2006.		
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations		
Other (as the proposer wishes to add)			

NAME OF THE COURSE	**OPTOELECTRONIC MEASUREMENT METHODS**						
Code	FELG33	Year of study	1				
Course teacher	Ivo Stančić, Ph.D., Assistant Professor	Credits (ECTS)	5				
Associate teachers		Type of instruction (number of hours)	L	S	AE	LE	DE
			30			30	
Status of the course	Elective	Percentage of application of e-learning	0				
COURSE DESCRIPTION							
Course objectives	Training students for: - Understand the basic principles of camera and optical lens elements - Operate with linear, IR / night and heat cameras - Apply camera to control industrial process or use it as a sensor - Operate and analyze data from laser range finders and LIDAR						
Course enrolment requirements and entry competences required for the course							

<table>
<tr><td>Learning outcomes expected at the level of the course (4 to 10 learning outcomes)</td><td colspan="4">Students will be able to:
– Have detail knowledge of camera and camera optical elements
– Apply algorithms for 3D reconstruction of motion
– Apply algorithm for surface reconstruction
– Analyze data from laser range finders and create map of area</td></tr>
<tr><td rowspan="28">Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="2">Course content</td><td>L hours</td><td>AE hours</td></tr>
<tr><td colspan="2">Introduction to optoelectronics</td><td>2</td><td></td></tr>
<tr><td colspan="2">Machinevisionaandcomputervision</td><td>2</td><td></td></tr>
<tr><td colspan="2">Mathematicaldescriptionofcamerasandgeometryof a space</td><td>4</td><td></td></tr>
<tr><td colspan="2">Lenseoptical system anddistorsions</td><td>2</td><td></td></tr>
<tr><td colspan="2">Color system andphotosensitivechips</td><td>2</td><td></td></tr>
<tr><td colspan="2">Inudstrialcameras, linearcameras, motioncapturesystems</td><td>2</td><td></td></tr>
<tr><td colspan="2">IR camerasandapplications</td><td>2</td><td></td></tr>
<tr><td colspan="2">Stereovisionsystems</td><td>2</td><td></td></tr>
<tr><td colspan="2">3D scanners</td><td>2</td><td></td></tr>
<tr><td colspan="2">Laser rangefindersand LIDAR</td><td>2</td><td></td></tr>
<tr><td colspan="2">Nightvisioncamerasandimageintensifiers</td><td>2</td><td></td></tr>
<tr><td colspan="2">Future ofoptoelectronics</td><td>2</td><td></td></tr>
<tr><td colspan="2">Introduction to optoelectronics</td><td>2</td><td></td></tr>
<tr><td colspan="3">List oflaboratoryor design exercises</td><td>LE hours</td></tr>
<tr><td colspan="3">Introduction to Matlab: image loading, capture and editing</td><td>2</td></tr>
<tr><td colspan="3">Introduction to Matlab: video loading, capture and editing</td><td>2</td></tr>
<tr><td colspan="3">Camera calibration and distortion removal</td><td>2</td></tr>
<tr><td colspan="3">Movement reconstruction from single camera in single plane</td><td>2</td></tr>
<tr><td colspan="3">Movement reconstruction with stereovision system in space</td><td>2</td></tr>
<tr><td colspan="3">Laser and IR rangefinders</td><td>2</td></tr>
<tr><td colspan="3">3D scanners and surface reconstruction</td><td>2</td></tr>
<tr><td colspan="3">Lidar and applications in robotics</td><td>2</td></tr>
<tr><td colspan="3">Cameras in visible and IR spectrum. Presentation of night optics</td><td>2</td></tr>
<tr><td colspan="3">IR thermal camera and temperature calculation</td><td>2</td></tr>
<tr><td>Format of instruction</td><td colspan="2">☐lectures
☐seminars and workshops
☐exercises
☐on linein entirety
☐partial e-learning
☐field work</td><td colspan="2">☒independent assignments
☒multimedia
☒laboratory
☐work with mentor
☐ (other)</td></tr>
<tr><td>Studentresponsibilities</td><td colspan="4"></td></tr>
<tr><td rowspan="5">Screening student work (name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)</td><td>Class attendance</td><td>1</td><td>Research</td><td></td><td>Practical training</td><td></td></tr>
<tr><td>Experimental work</td><td></td><td>Report</td><td></td><td>Impended research</td><td>1,7</td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td>1</td><td>Laboratory exercises</td><td>1</td></tr>
<tr><td>Tests</td><td>0,2</td><td>Oral exam</td><td></td><td>(Other)</td><td></td></tr>
<tr><td>Written exam</td><td>0,1</td><td>Project</td><td></td><td>(Other)</td><td></td></tr>
</table>

<table>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="3">During the semester there are two midterm exams according to teaching calendar or project assignments will be handed out depending on student preferences.

The requirement for passing grade is the positive assessment of laboratory exercises and 50 % points on average midterm exam ((M1 + M2)/2) or the final exam. Students are allowed to have at least 45% of total points on each midterm exams, as long as the final midterm average is at least 50% of total points.

Midterm consists of both theoretical questions and numerical problems. The midterms consist of 4 questions while final exam test consists of 6 questions divided into two groups.

In determining the final grade (in percentages) each midterm contributes with 30% (or project assignment with 60%), while laboratory exercises contribute with 40%.

Final grade (based on percentages) is formed as follows:

Percentage Grade
50% do 62% sufficient (2)
63% do 74% good (3)
75% do 86% very good (4)
87% do 100% excellent (5)

In case student does not complete midterms or project exams he/she needs to take the final exam in which case it contributes with 60% toward final grade, and laboratory exercises again with 40%.</td></tr>
<tr><td rowspan="3">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>• Hartley, R., Zisserman, A.: ‘Multipleviewgeometryincomputervision’ (Cambridge University Press, 2003)</td><td></td><td></td></tr>
<tr><td>• Shapiro, G., Stockman, G.C.: ‘Computer vision’ (Prentice-Hall, 2001)</td><td></td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3"></td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Keeping records of student attendance.
- Annual analysis of course statistics in terms of midterm and finals exams.
- Feedback from students via surveys.
- Teacher self-evaluation.
- Feedback from graduated students (or senior students) on course content relevance.</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3">/</td></tr>
</table>

NAME OF THE COURSE	OPTIMIZATION AND OPTIMAL SYSTEMS						
Code	FELG23	Year of study	2.				
Course teacher	Mirjana Bonković, Ph.D., FullProfessor	Credits (ECTS)	5				
Associate teachers		Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for adoptionandunderstandingofthebasicknowledgeof:optimizationprocedures for solvingproblemsinthefieldsofengineering, such as robot control, productionplanningand / oranalysis (understanding) theimagecontent.		
Course enrolment requirements and entry competences required for the course			
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - Applyoptimizationmethods to engineeringproblems, includingdeveloping a model, defininganoptimization problem, applyingoptimizationmethods, exploringthesolutionandinterpretingresults. - Understandandapplyunconstrainedoptimizationtheory for continuousproblems, includingthenecessaryandsufficientconditionsandsteepestdescent, Newton'smethod, conjugategradientandquasi-Newton methods. Understandbasictheoremsofquasi-Newton methods. - Understandandapplydiscretealgorithms, includingbranchandbound, exhaustivesearchandsimulatedannealing. - Understandandapplythesimplexalgorithm for solvinglinearproblemswithconstraints. - Have some familiaritywithoptimization software.		
Course content broken down in detail by weekly class schedule (syllabus)	Course content		L hours AE hours
	Introduction. Modelsofengineeringoptimization.		2
	Mathematicalmodeling. Objectivefunction.		2
	Performanceoffeedbackcontrol system.		4
	Optimizationwithoutconstraints. Gradientmethod. Newton'smethod.		4
	Discreteoptimization. Simulatedannealing. Geneticalgorithms.		4
	Optimizationwithconstraints. Linearprogramming. Simplexalgorithm.		4
	Non-linearoptimizationwithconstraints.		4
	Thecalculusofvariations.		2
	Casestudies: Applicationofnonlinearoptimizationmethods for visualservoing.		2
	Analysisand processing ofmedicalimages .		6
Format of instruction	☒lectures ☐seminars and workshops ☐exercises ☐*on line*in entirety ☐partial e-learning ☐field work	☒independent assignments ☒multimedia ☐laboratory ☒work with mentor ☐ (other)	
Studentresponsibilities			

	Class attendance	2	Research		Practical training	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Experimental work		Report		Individual work	1
	Essay		Seminar essay		Laboratory exercises	0
	Tests	0,3	Oral exam		Preparation for laboratory exercises	0
	Written exam	**0,3**	Project	1,4	(Other)	

Grading and evaluating student work in class and at the final exam	During the semester, students receive smaller project tasks that have to be addressed. In addition, there are two midterm exams. The first midterm exam is after 7 weeks of lectures and the second one is after 13 weeks of lectures (in a form of presentation and defense of the project assignment). Each midterm test (as well as the final test) is carried out in a written format with duration of 90 minutes. The requirement for passing grade is the positive assessment of project tasks and 50 % points on average midterm exam ((M1 + M2)/2) or the final exam. Students are allowed to have at least 45% of total points on each midterm exams, as long as the final midterm average is at least 50% of total points. Grade (in percentage) is formed according to the formula: Grade(%) = 0,5M1 + 0,5M2 where: • M1, M2 – midterm test results. It is possible to be relieved of the midterm exams in case of making extensive smaller project tasks. According to Article 65. of Faculty's Bylaw, student is required to participate in all teaching activities attending at least 70% of lectures, and 100% of laboratory exercises. If student does not meet these criteria, she or he won't be able to take part in the final exam, and will be required to enroll in the course the next year.

	Title	**Number of copies in the library**	**Availability via other media**
Required literature (available in the library and via other media)	D. Pierre, OptimizationTheoryWithApplications, John Willey&Sons, New York, 1969.		e-learning
	M. Bonković: Autorizirana predavanja, FESB		e-learning
	http://apmonitor.com/me575/index.php/Main/BookChapters (10.03.2017.)		
	V. Zanchi, Optimizacija, Sveučilište u Splitu, 1983.		e-learning

Optional literature (at the time of submission of study programme proposal)	- Kamran Iqubal: Fundamental Engineering Optimization Methods, bookboon.com (19.03.2017.) - Numerical Recipes in C (or C++) : The Art of Scientific Computing, by William H. Press, Brian P. Flannery, Saul A. Teukolsky, William T. Vetterling. - Convex Optimization, Stephen Boyd & Lieven Vandenberghe, 2004 - Stephen Boyd on Convex Optimizations pdfs video lectures
Quality assurance methods that ensure the acquisition of exit competences	- Keeping records of student attendance. - Annual analysis of course statistics in terms of midterm and finals exams. - Feedback from students via surveys. - Teacher self-evaluation. - Feedback from graduated students (or senior students) on course content relevance. - Periodic institutional evolution of course teachers.
Other (as the proposer wishes to add)	

NAME OF THE COURSE	MICROCONTROLLERS AND NETWORK EMBEDDED SYSTEMS						
Code	FELG24	Year of study	2.				
Course teacher	Mirjana Bonković, Ph.D., FullProfessor	Credits (ECTS)	5				
Associate teachers	Ivo Stančić, Ph.D., AssistantProfessor	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students: - to develop an understanding for the purpose and the design principles of the embedded systems - to develop an understanding of basic microcontroller architecture - to be familiar with concept of microcontroller interfaces - to be able to create embedded system that communicates via a local Ethernet network and the Internet	
Course enrolment requirements and entry competences required for the course	Finished programming course.	
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - define and understand the basic concepts related to the process of designing the embedded system. - define and understand the interfacing techniques - program the related microcontrollers' peripheral systems to establish the appropriate functionality of the embedded system - design the embedded system in the Arduino environment that reflect the functionality based on the information processing acquired from the sensors. - apply a procedure that provides network data transmission from sensor to the processing unit - apply a procedure which ensures the functionality of the embedded system through web interface.	
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours
	The purpose of a microcontroller. Embedded system design principles.	2
	Embedded system design in Arduino environment.	2
	Knowledge and understanding of fundamental embedded systems design paradigms, architectures, possibilities and challenges, both with respect to software and hardware.	2
	Microprocessor peripheral devices. General purpose input output.	2
	Serial communication: SPI, USART, IIC.	4
	Real time clock. Timers.	2
	A / D and D / A converters. Realization of A / D converters.	2
	Interrupts. Programming interrupts.	2
	Architecture and functional microprocessors' components for network communication.	2
	Using IP for local and Internet communications. Exchanging messages using UDP and TCP, e-mail. Alarm system.	2
	Using the Web interface.	2
	Optimization of the embedded system regarding the energy consumption	2
	List of laboratory or design exercises	LEhours
	Introduction to the Arduino development environment: hardware componentsandprogramming mode.	2
	Digital input - output. Serial Monitor.	2
	Analog input. PWM output.	2

	Speedcontrolof DC motors.	2
	Using GPS module.	2
	Using NRF modules.	2
	Sensors: OneWire temperature sensor, analogsensor (gyroscope), IIC sensor.	2
	Ethernet shild. Exchangingmessagesusing UDP and TCP.	2
	Web server (withandwithoutfeedback), e-mail, alarm system.	2
	Optimization of the embedded system regarding the energy consumption	2
	Student projects.	6

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐*on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☒ multimedia ☒ laboratory ☒ work with mentor ☐ (other)
Studentresponsibilities		

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	2	Research		Practical training	
	Experimental work		Report		Individual work	0,6
	Essay		Seminar essay	1	Laboratory exercises	0,8
	Tests	0,2	Oral exam		Preparation for laboratory exercises	0,2
	Written exam	**0,2**	Project		(Other)	

Grading and evaluating student work in class and at the final exam	During the semester there are two midterm exams. The first midterm exam is after 7 weeks of lectures and the second one is after 13 weeks of lectures (in a form of presentation and defense of the project assignment). Each midterm test (as well as the final test) is carried out in a written format with duration of 90 minutes. The requirement for passing grade is the positive assessment of laboratory exercises and 50 % points on average midterm exam ((M1 + M2)/2) or the final exam. Students are allowed to have at least 45% of total points on each midterm exams, as long as the final midterm average is at least 50% of total points. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1L + 0,4M1 + 0,5M2 where: • L – laboratory assessment, • M1, M2 – midterm test results. According to Article 65. of Faculty's Bylaw, student is required to participate in all teaching activities attending at least 70% of lectures, and 100% of laboratory exercises. If student does not meet these criteria, she or he won't be able to take part in the final exam, and will be required to enroll in the course the next year.

	Title	**Number of copies in the library**	**Availability via other media**
Required literature (available in the library and via other media)	Steven F. Barrett, Arduino Microcontroller Processing for Everyone!, SynthesisLectures on Digital Circuitsand Systems, Morgan &ClaypoolPublishers, 2010.		
	David Russeell, Introduction to Embedded Systems Using ANSI C andthe Arduino Development Environment, SynthesisLectures on Digital		

	Circuitsand Systems, Morgan &ClaypoolPublishers, 2010.		
	Michael Predko , HandbookofMicrocontrollers, TabBooks, 1998.		
	M. Bonković, J. Musić, I. Stančić, Mikroregulatori i ugradbeni mrežni sustavi, FESB, 2014.		e-learning
Optional literature (at the time of submission of study programme proposal)	1. Claus Kuhnel, Klaus Zahnert, BASIC Stamp : An Introduction to Microcontrollers,Newnes, 2000. 2. Han-Way Huang, PIC Microcontroller, Thomson Delmar Learning, 2004. 3. Jan Axelson: Embedded Ethernet and Internet complete, Lakeview Research LLC, 2003., ISBN: 1-931448-00-0 - Microcontroller links http://people.westminstercollege.edu/faculty/rerickson/control/stamplinks.html		
Quality assurance methods that ensure the acquisition of exit competences	- Keeping records of student attendance. - Annual analysis of course statistics in terms of midterm and finals exams. - Feedback from students via surveys. - Teacher self-evaluation. - Feedback from graduated students (or senior students) on course content relevance. - Periodic institutional evolution of course teachers.		
Other (as the proposer wishes to add)			