UNIVERSITY OF SPLIT

FACULTY OF ELECTRICAL ENGINEERING, MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE

DETAILED PROPOSAL OF THE STUDY PROGRAMME

GRADUATE UNIVERSITY STUDY IN AUTOMATION AND SYSTEMS

SPLIT, February 2022

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
	* 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	
	FELH35	Solar cells	30	0	0	30	0	5
	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.

	Title	**Number of copies in the library**	**Availability via other media**
Required literature (available in the library and 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 library and via other media)	**Title**	**Number of copies in the library**	**Availability 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	Students will be able to: - explain computer and telecommunication basis for telemedicine.						

10 learning outcomes)	- 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 broken down in detail by weekly class schedule (syllabus)	Course content	L 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*	Class attendance	1	Research		Practical training	
	Experimental work		Report		Individual work	2

credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)	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 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.

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• I. Klapan, I. Čikeš:; Telemedicina u Hrvatskoj, Medika, Zagreb, 2001.	3	teacher
	• R. J. Jagacinski, J. M. Flach: Control Theory for Humans: Quantitative Approaches to Modeling Performance, Lawrence Erlbaum Associates Inc., 2003		teacher
	• T. Marasović, Guidelines for laboratory exercises, FESB		e-learning portal
	• M. Cecić, J. Musić: Authorized lecture notes, FESB		e-learning portal
Optional literature (at the time of submission of study programme proposal)	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.
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	**SOLAR CELLS**							
Code	FELH35	Year of study	1					
Course teacher	Tihomir Betti, Ph.D., Assistant Professor Ivan Marasović, 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						
COURSE DESCRIPTION								
Course objectives	Training students for: - Understanding fundamental operating principles of solar cells. - Modeling solar cells using equivalent electrical circuits. - Calculating solar radiation on the plane of arbitrary tilt and orientation. - Understanding different PV technologies and comparison between them. - Designing simple stand-alone and grid-connected PV systems. - Calculating the electricity production of a photovoltaic system.							
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: - Calculate the components of solar radiation on the plane of arbitrary tilt and orientation. - Explain the physical operating principles of a solar cell. - Compare different solar cell technologies.							

<table>
<tr><td></td><td colspan="6">- Design simple grid-connected and stand-alone photovoltaic system.
- Calculate the electricity production of a photovoltaic system.</td></tr>
<tr><td rowspan="23">Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="5">Course content</td><td>L hours</td></tr>
<tr><td colspan="5">Introduction. Solar radiation: irradiance and irradiation. Basic solar geometry parameters.</td><td>2</td></tr>
<tr><td colspan="5">Solar radiation components. Measurement of solar radiation. Calculating the beam, diffuse and reflected solar radiation.</td><td>2</td></tr>
<tr><td colspan="5">Physical principles of solar cell operation. Current-voltage characteristic and basic solar cell parameters. Series and shunt resistance.</td><td>2</td></tr>
<tr><td colspan="5">Solar cell models. Dependence of solar cell parameters on irradiance and temperature.</td><td>2</td></tr>
<tr><td colspan="5">Amorphous silicon solar cells.</td><td>2</td></tr>
<tr><td colspan="5">Crystalline silicon solar cells.</td><td>2</td></tr>
<tr><td colspan="5">High-efficiency III-V multijunction solar cells. Other semiconductor materials for solar cells.</td><td>2</td></tr>
<tr><td colspan="5">Organic solar cells.</td><td>2</td></tr>
<tr><td colspan="5">Third generation solar cells: concepts and perspective. Nanostructure-based solar cells.</td><td>2</td></tr>
<tr><td colspan="5">Photovoltaic systems: stand-alone and grid-connected. Photovoltaic system components: inverters, charge regulators, batteries, mounting structures, cables.</td><td>2</td></tr>
<tr><td colspan="5">Design of grid-connected and stand-alone photovoltaic system. Shading and mismatch losses. Hot spot heating.</td><td>2</td></tr>
<tr><td colspan="5">Estimation of electricity production of a photovoltaic system.</td><td>2</td></tr>
<tr><td colspan="5">PV cell, module and system testing. Environmental impact of a photovoltaic system. Photovoltaics in the smart grid.</td><td>2</td></tr>
<tr><td colspan="5">List of laboratory or design exercises</td><td>LE hours</td></tr>
<tr><td colspan="5">Solar radiation. Measurement of solar radiation.</td><td>3</td></tr>
<tr><td colspan="5">Calculating global horizontal radiation from sunshine duration</td><td>3</td></tr>
<tr><td colspan="5">Estimation of solar radiation on surface of arbitrary tilt and orientation.</td><td>6</td></tr>
<tr><td colspan="5">Shade measurement and solar site assessment.</td><td>3</td></tr>
<tr><td colspan="5">Design of grid-connected photovoltaic system.</td><td>6</td></tr>
<tr><td colspan="5">Estimating electricity production of a photovoltaic system.</td><td>3</td></tr>
<tr><td colspan="5">Visiting photovoltaic system on the roof of the faculty building.</td><td>3</td></tr>
<tr><td colspan="5">Testing photovoltaic modules and systems. Photovoltaic system in the smart energy systems (smart home and smart grid).</td><td>3</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</td><td colspan="3">☒ independent assignments
☒ multimedia
☒ laboratory
☐ work with mentor
☐ (other)</td></tr>
<tr><td>Studentresponsibilities</td><td colspan="6">At least 70% of lectures attendance. Completed all laboratory assignments and the presentation of two projects.</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>Individual work</td><td>2</td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td></td><td>Laboratory exercises</td><td>1</td></tr>
<tr><td>Tests</td><td>0.15</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>0.75</td><td>(Other)</td><td></td></tr>
<tr><td>Grading and evaluating student</td><td colspan="6">Students work in groups of two on two projects: the first project involves calculation of global solar radiation from sunshine duration, the evaluation of the model used and calculation of solar energy on slope of arbitrary tilt and orientation. The first project is</td></tr>
</table>

<table>
<tr><td>work in class and at the final exam</td><td colspan="3">presented during the first midterm exam (after 7 weeks of classes). The second project is design of a photovoltaic system and students must complete it and present the results during the second midterm exam (after the following 6 weeks of classes). Apart from presentation of student projects, there will be two midterm quizzes. The requirement for passing the course is to score at least 40% at each quiz, complete all laboratory work and successfully present the projects.. The final grade (in percentage) is formed using following formula:
Grade(%)=0.3(M1+M2)+0.4P,
where:
• M1, M2 – grade from midterm exams given in percentage,
• P – grade from projects given in percentage.
Students notpassingthemidtermexams take partinthefinalexams. For passingthefinalexam, students must score at least 50% as well as have a positiveassesmentofthelaboratoryexercises. The grade on finalexamsisdeterminedbythe formula:
Grade(%) = 0.65F+0.35P,
where:
• P – grade from projects given in percentage.</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 library</td><td>Availability via other media</td></tr>
<tr><td>• T. Betti, I. Marasović: Sunčanećelije – autoriziranapredavanja (prezentacije), FESB</td><td></td><td>E-learning portal</td></tr>
<tr><td>• P. Kulišić, J. Vuletin, I. Zulim: Sunčane ćelije, Školska knjiga, Zagreb, 1994.</td><td></td><td></td></tr>
<tr><td>• PlanningandInstallingPhotovoltaic Systems, 2nd edition, Earthscan, 2010.</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">- T. Markvart, L. Castañer: Practical Handbook of Photovoltaics: Fundamentals and Applications, Elsevier, 2003.
- M.A. Green: Solar cells: operating principles, technology, and system applications, Prentice-Hall, 1982.
- A. Luque, S. Hegedus: Handbook of Photovoltaic Science and Engineering, Wiley, 2003.
- S.M. Sze, K.K. Ng: Physics of Semiconductor Devices, Wiley, 2006.
- M.A. Green: Third Generation Photovoltaics, Springer, 2006.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Record of number of students attending the classes
- Evaluation of results in accordance with expected learning outcomes
- Feedback from students via student surveys
- Teachers self-evaluation
- 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	**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: 30; S: ; AE: ; LE: 30; DE:
Status of the course	Elective	Percentage of application of e-learning	0

L	S	AE	LE	DE
30			30	

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	
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	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

Course content broken down in detail by weekly class schedule (syllabus)

Course content	L hours	AE hours
Introduction to optoelectronics	2	
Machinevisionaandcomputervision	2	
Mathematicaldescriptionofcamerasandgeometryof a space	4	
Lenseoptical system anddistorsions	2	
Color system andphotosensitivechips	2	
Inudstrialcameras, linearcameras, motioncapturesystems	2	
IR camerasandapplications	2	
Stereovisionsystems	2	
3D scanners	2	
Laser rangefindersand LIDAR	2	
Nightvisioncamerasandimageintensifiers	2	
Future ofoptoelectronics	2	
Introduction to optoelectronics	2	

List oflaboratoryor design exercises	LE hours
Introduction to Matlab: image loading, capture and editing	2
Introduction to Matlab: video loading, capture and editing	2
Camera calibration and distortion removal	2
Movement reconstruction from single camera in single plane	2
Movement reconstruction with stereovision system in space	2
Laser and IR rangefinders	2
3D scanners and surface reconstruction	2
Lidar and applications in robotics	2
Cameras in visible and IR spectrum. Presentation of night optics	2
IR thermal camera and temperature calculation	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)
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	1	Research		Practical training	
	Experimental work		Report		Impended research	1,7
	Essay		Seminar essay	1	Laboratory exercises	1
	Tests	0,2	Oral exam		(Other)	
	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 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%.

	Title	**Number of copies in the library**	**Availability via other media**
Required literature (available in the library and via other media)	• Hartley, R., Zisserman, A.: 'Multipleviewgeometryincomputervision' (Cambridge University Press, 2003)		
	• Shapiro, G., Stockman, G.C.: 'Computer vision' (Prentice-Hall, 2001)		

Optional literature (at the time of submission of study programme proposal)	
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.
Other (as the proposer wishes to add)	/

<table>
<tr><td>NAME OF THE COURSE</td><td colspan="7">OPTIMIZATION AND OPTIMAL SYSTEMS</td></tr>
<tr><td>Code</td><td>FELG23</td><td>Year of study</td><td colspan="5">2.</td></tr>
<tr><td>Course teacher</td><td>Mirjana Bonković, Ph.D., FullProfessor</td><td>Credits (ECTS)</td><td colspan="5">5</td></tr>
<tr><td rowspan="2">Associate teachers</td><td rowspan="2"></td><td rowspan="2">Type of instruction (number of hours)</td><td>L</td><td>S</td><td>AE</td><td>LE</td><td>DE</td></tr>
<tr><td>30</td><td>0</td><td>0</td><td>30</td><td>0</td></tr>
<tr><td>Status of the course</td><td>Obligatory</td><td>Percentage of application of e-learning</td><td colspan="5">0</td></tr>
<tr><td colspan="8">COURSE DESCRIPTION</td></tr>
<tr><td>Course objectives</td><td colspan="7">Training students for adoptionandunderstandingofthebasicknowledgeof:optimizationprocedures for solvingproblemsinthefieldsofengineering, such as robot control, productionplanningand / oranalysis (understanding) theimagecontent.</td></tr>
<tr><td>Course enrolment requirements and entry competences required for the course</td><td colspan="7"></td></tr>
<tr><td>Learning outcomes expected at the level of the course (4 to 10 learning outcomes)</td><td colspan="7">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.</td></tr>
<tr><td rowspan="9">Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="6">Course content</td><td>L hours
AE hours</td></tr>
<tr><td colspan="6">Introduction. Modelsofengineeringoptimization.</td><td>2</td></tr>
<tr><td colspan="6">Mathematicalmodeling. Objectivefunction.</td><td>2</td></tr>
<tr><td colspan="6">Performanceoffeedbackcontrol system.</td><td>4</td></tr>
<tr><td colspan="6">Optimizationwithoutconstraints. Gradientmethod. Newton'smethod.</td><td>4</td></tr>
<tr><td colspan="6">Discreteoptimization. Simulatedannealing. Geneticalgorithms.</td><td>4</td></tr>
<tr><td colspan="6">Optimizationwithconstraints. Linearprogramming. Simplexalgorithm.</td><td>4</td></tr>
<tr><td colspan="6">Non-linearoptimizationwithconstraints.</td><td>4</td></tr>
<tr><td colspan="6">Thecalculusofvariations.</td><td>2</td></tr>
</table>

<table>
<tr><td></td><td colspan="5">Casestudies: Applicationofnonlinearoptimizationmethods for visualservoing.</td><td>2</td></tr>
<tr><td></td><td colspan="5">Analysisand processing ofmedicalimages .</td><td>6</td></tr>
<tr><td>Format of instruction</td><td colspan="3">☒lectures
☐seminars and workshops
☐exercises
☐on linein entirety
☐partial e-learning
☐field work</td><td colspan="3">☒independent assignments
☒multimedia
☐laboratory
☒work with mentor
☐ (other)</td></tr>
<tr><td>Studentresponsibilities</td><td colspan="6"></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>2</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>1</td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td></td><td>Laboratory exercises</td><td>0</td></tr>
<tr><td>Tests</td><td>0,3</td><td>Oral exam</td><td></td><td>Preparation for laboratory exercises</td><td>0</td></tr>
<tr><td>Written exam</td><td>0,3</td><td>Project</td><td>1,4</td><td>(Other)</td><td></td></tr>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="6">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.</td></tr>
<tr><td rowspan="5">Required literature (available in the library and via other media)</td><td colspan="4">Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td colspan="4">D. Pierre, OptimizationTheoryWithApplications, John Willey&Sons, New York, 1969.</td><td></td><td>e-learning</td></tr>
<tr><td colspan="4">M. Bonković: Autorizirana predavanja, FESB</td><td></td><td>e-learning</td></tr>
<tr><td colspan="4">http://apmonitor.com/me575/index.php/Main/BookChapters (10.03.2017.)</td><td></td><td></td></tr>
<tr><td colspan="4">V. Zanchi, Optimizacija, Sveučilište u Splitu, 1983.</td><td></td><td>e-learning</td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="6">- 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.</td></tr>
</table>

	- 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	Course content	L hours					
	The purpose of a microcontroller. Embedded system design principles.	2					

class schedule (syllabus)	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.

<table>
<tr><td></td><td colspan="3">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.</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>Steven F. Barrett, Arduino Microcontroller Processing for Everyone!, SynthesisLectures on Digital Circuitsand Systems, Morgan &ClaypoolPublishers, 2010.</td><td></td><td></td></tr>
<tr><td>David Russeell, Introduction to Embedded Systems Using ANSI C andthe Arduino Development Environment, SynthesisLectures on Digital Circuitsand Systems, Morgan &ClaypoolPublishers, 2010.</td><td></td><td></td></tr>
<tr><td>Michael Predko , HandbookofMicrocontrollers, TabBooks, 1998.</td><td></td><td></td></tr>
<tr><td>M. Bonković, J. Musić, I. Stančić, Mikroregulatori i ugradbeni mrežni sustavi, FESB, 2014.</td><td></td><td>e-learning</td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">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</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.
- Periodic institutional evolution of course teachers.</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
</table>