NAME OF THE COURSE	Electromagnetic Fields in the Environment						
Code	PMP266	Year of study	1				
Course teacher	Dragan Poljak, PhD, Full Professor	Credits (ECTS)	4				
Associate teachers	Anna Šušnjara, mag. ing.	Type of instruction (number of hours)	L	S	E	F	
			30		30		
Status of the course	Elective	Percentage of application of e-learning					

COURSE DESCRIPTION

Course objectives	train students for: - understanding and application of basic principles of electromagnetic and thermal dosimetry - assessment of human exposure to electromagnetic field sources of low and high frequency using mathematical models - permanent acquisition and deepening of knowledge in the field of bioelectromagnetism - application of domestic and international legislation to the assessment of human exposure to non-ionizing radiation
Course enrolment requirements and entry competences required for the course	- Electrodynamics 1 - Electrodynamics 2
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	After successfully mastering the course, students will be able to: - define basic concepts in bio-electromagnetism - apply methods of measuring external fields of low and high frequencies - apply methods of calculation of external fields of low and high frequencies - analyse the level of exposure of the human body to non-ionizing radiation by application international and domestic legislation - calculate the basic parameters of internal field dosimetry using simple and complex models of the human body - use of commercial software packages for the application of realistic dosimetry models of the human body
Course content broken down in detail by weekly class schedule (syllabus)	1. Electrosmog: electromagnetic pollution of the environment. Electromagnetic spectrum. Ionizing and non-ionizing radiation (2 hours of lectures and 1 hour of exercises) 2. Mechanisms of coupling of electromagnetic field and human body. Biological effects of electromagnetic fields. Effects at low and high frequencies. Epidemiological and statistical studies (2 hours of lectures and 1 hour of exercises) 3. Basic values of electromagnetic dosimetry, current density, external and internal fields, induced electric field, specific absorbed power density (SAR), specific absorption (SA), incident power density (2 hours of lectures and 1 hour of exercises) 4. Guidelines for protection against non-ionizing radiation. Domestic and international legislation. Basic constraints and reference levels. Protection measures (2 hours of lectures and 1 hour of exercises) 5. Methods of theoretical and experimental dosimetry. Incident and internal field dosimetry. Deterministic and stochastic models (2 hours of lectures and 1 hour of exercises) 6. Dosimetry of the incident field; Characterization of radiation sources. Calculation and measurements of electric field at low frequencies. Exposure to overhead lines and transformer stations (2 hours of lectures and 1 hour of exercises) 7. Incidence field dosimetry; Calculation and measurements of electromagnetic field at high frequencies. Exposure to RFID antennas, mobile phones, base stations (2 hours of lectures and 1 hour of exercises) 8. Classification of models for internal dosimetry. Simplified and anatomical body

	models (2 hours of lectures and 1 hour of exercises) 9. Electromagnetic modeling of the body at low frequencies. Whole body exposure to low frequency fields (2 hours of lectures and 1 hour of exercises) 10. Electromagnetic modeling of bodies at high frequencies. Exposure of the whole body, eye, brain and whole head to non-ionizing radiation (2 hours of lectures and 1 hour of exercises) 11. Exposure of the human body to transient radiation (2 hours of lectures and 1 hour of exercises) 12. Thermal response of the human body exposed to high frequency electromagnetic radiation. Thermal response of the eye, brain and whole head due to exposure to high frequency fields (2 hours of lectures and 1 hour of exercises) 13. Biomedical applications of electromagnetic fields. Electrical nerve stimulation. Laser radiation of the eye. Methods of stimulating the human brain. Transcranial magnetic stimulation. Transcranial electrical stimulation (2 hours of lectures and 1 hour of exercises) Laboratory exercises - Human exposure to non-ionizing EM radiation (frequencies up to 10 MHz) - simulation models (2 hours of exercises) - Human exposure to non-ionizing EM radiation (frequencies above 10 MHz) - simulation models (2 hours of exercises) - Measuring instruments and measuring methods for estimating exposure to EM fields (3 hours exercises) - Measurement of low frequency electric fields (2 hours of exercises) - Measurement of low frequency magnetic fields (2 hours of exercise) - Measuring EM field at high frequencies (2 hours of exercise) - EM field calculations in the base station environment (2 hours of exercise)

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	Attend at least 70% of lectures and 70% of 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	1.8	Research		Practical training	
	Experimental work	0.2	Report		Partial written exam	0.1
	Essay		Seminar essay		(Other)	
	Tests		Oral exam		(Other)	
	Written exam	0.1	Project	1.8	(Other)	

Grading and evaluating student work in class and at the final exam	Two colloquia (intermediate exams) will be held during the semester. The first colloquium is held after 7 weeks of classes, and the second after the next 6 weeks. At the final exam, students take parts of the material that they did not pass in the colloquia. Each colloquium is conducted as a written exam lasting 75 minutes and consists of a total of 10 questions / assignments. The conditions for a positive grade are completed laboratory exercises and a minimum of 50% of points in both colloquia, and the final grade is formed as follows: Grade (%) = 0.5 (K1 + K2) where K1 and K2 - grades achieved in colloquia.

The final grade is determined in accordance with the achieved percentages in the following way:

Percentage Rating
50% to 62% sufficient (2)
63% to 75% good (3)
76% to 88% very good (4)
89% to 100% excellent (5)

Students who have not passed the exam through the colloquium take the exam in the winter / autumn term. If a student has passed one of the colloquia, he / she takes the material from the colloquium in which he / she did not achieve a satisfactory number of points. The exam is conducted in written form for 90 minutes and consists of a total of 10 questions / assignments. The condition for a positive grade is a minimum of 50% of the points achieved in the exam. The total score is determined in accordance with the achieved percentages in the manner described.

<table>
<tr><td rowspan="5">Required literature (available in the library and via other media)</td><th>Title</th><th>Number of copies in the library</th><th>Availability via other media</th></tr>
<tr><td>D.Poljak, M. Cvetković

Human Interaction with Electromagnetic Fields: Computational Models in Dosimetry

Elsevier, 2019.</td><td>0</td><td>Yes</td></tr>
<tr><td>D. Poljak, K. El Khamlichi Drissi

Computational Methods in Electromagnetic Compatibility, Antenna Theory Approach versus Transmission Line Models

Wiley, 2018.</td><td>0</td><td>yes</td></tr>
<tr><td>D.Poljak

Teorija elektromagnetskih polja s primjenama u inženjerstvu

Školska knjiga Zagreb, 2014.</td><td>5</td><td>yes</td></tr>
<tr><td>D. Poljak

Izloženost ljudi elektromagnetskom zračenju

Kigen, Zagreb, 2007.</td><td>5</td><td>yes</td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">D. Poljak,
Advanced Modeling in Computational Electromagnetic compatibility
Wiley Interscience, 2007.

D. Poljak
Human Exposure to Electromagnetic Fields,
WIT Press, 2003.

R.W.Y. Habash</td></tr>
</table>

	Electromagnetic Fields and Radiation Marcel Dekker, 2002. D. Poljak **Exposure of Humans to Electromagnetic Radiation** SoftCOM Library, 2002.
Quality assurance methods that ensure the acquisition of exit competences	Exam results statistics and student evaluation through an anonymous survey at the end of the course. The survey is conducted according to the regulations of the University of Split.
Other (as the proposer wishes to add)	In the situation that the course is attended by a smaller number of students, instead of the classic exam, it is possible to monitor the work of students through seminar work.