1. GENERAL INFORMATION					
Study programme title	Mining engineering Subprogramme waste treatment and disposal				
Course title	Underground repositories		**Semester**	3	
Teacher	Želimir Veinović		**Course code**	27118	
Course type	☒ obligatory ☐ elective		**ECTS**	4,5	
Location					
Language	☒ Croatian ☒ English				

Class type	Weekly hours	Teaching staff	Office hours	Room	E-mail
Class	30	Želimir Veinović, PhD, Assistant professor	10,00-12,00	V504	zelimir.veinovic@rgn.hr
Practice	30	Želimir Veinović, PhD, Assistant professor	10,00-12,00	V504	zelimir.veinovic@rgn.hr
Field lecture	7,5	Želimir Veinović, PhD, Assistant professor	10,00-12,00	V504	zelimir.veinovic@rgn.hr

E-learning level	2	**Percentage of on-line class (max. 20%)**	5%

2. COURSE DESCRIPTION	
Course aims	Along with the basics of nuclear physics and introductory part about radionuclides and the application of nuclear energy, radioactive materials and the formation of radioactive waste, knowledge of the current state of management of radioactive and nuclear materials or waste in the Republic of Croatia and the world is communicated. The student learns about the properties and characteristics of radioactive waste and the methods of conditioning and pre-treatment of radioactive waste. The design and characteristics of surface, shallow and deep geological repositories of radioactive waste will be explained, with alternative concepts and designs of repositories. The student learns about the concept of multiple engineering barriers and the choice of appropriate rock material according to structural characteristics. The effects of

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	discontinuities and fractures on the repository's safety will be explained, as well as the ways in which the containers are installed in the rock and the filling technologies of the excavated areas.
Requirements for applicants	Conditions: Bachelor of science of technical sciences (mining, geotechnics, geology, civil engineering, mechanical engineering, etc.) or natural sciences (physics, chemistry, geology, etc.) or in environmental engineering. Competences: Students are acquired to have basic knowledge in nuclear physics.
Programme level learning outcomes with course contribution	Understanding principles of modern radioactive waste management. Possibility of analysing and validating system or components of the radioactive waste management, including its environmental impact. Valorise safety case.
Expected course level learning outcomes (4-10 outcomes)	Students will acquire knowledge and ability to recognize, understand, analyse, anticipate and address structural and strategic issues related to the disposal of radioactive waste in rock mass. The student acquires the knowledge necessary to solve concrete obstacles in the construction of the landfill under the specified conditions. Critical thinking and analysis of particular cases will help the student to predict specific behaviours, understand and objectively consider the results of the developed models.

Course contents by individual lessons

Class	Practice
L01 - Special or hazardous waste; Relying on nuclear energy in the world; Past, History ... What Is Radioactive Waste (RW)?	P01 - Getting to know the state of EREHWON: Topography, Geological Survey, Economic Diversity, Politics. ALTERNATIVE: Republic of Croatia ALTERNATIVE: state of choice
L02 - Ionizing Radiation, Electromagnetic Radiation, basics of nuclear physics	P02 - Example Analysis: Slovenia Checking the current state and knowledge/attitude of the population (making a survey leaflet)
L03 - Nuclear and radiological accidents	P03 - Example Analysis: Hungary Education and/or informing the population (making a scenario for TV commercial)

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L04 - Storage History of RW	P04 - Case Analysis: UK Organization of the Information centre
L05 - Croatia's Experience and the Situation in Croatia	P05 - Example Analysis: Spain Application of acquired knowledge in selected country - PROJECT DEVELOPMENT - Division into teams
L06 - Legislation: in the Republic of Croatia and the recommendations of the International Agency for Nuclear Energy (IAEA)	P06 - Example Analysis: France Regulators / implementers / governments - how to involve them and link them, develop legislation
L07 - Types and categories of RW	P07 - Example Analysis: Sweden Communication with local administrations (letter to local community)
L08 – Possible disposal solutions	P08 - Example Analysis: Finland Selection of experts - organization of working groups
L09 – Site selection	P09 - Example Analysis: Switzerland Site selection
L10 – Surface and shallow repositories	P10 - Example analysis: Germany Site Analysis
L11 – Deep geological repositories	P11 - Example Analysis: Japan Choice of method and technology
L12 – Design and technological processes	P12 - Development of method and technology on the project
L13 – Underground research facilities; Natural analogues	P13 - Development of method and technology on the project
L14 – Stakeholder involvement and dialogue	P14 - Consultations before project defence - separate work with teams
L15 – Project defence	P15 - Project defence

Students' obligations	Regular presence at the class (maximum absence 3 times), several practical tasks (design of pamphlet, commercial, official letter…), written (accepted by the teacher) and defended project.			
Students' work track *(indicate share in ECTS points for each activity so that overall ECTS number corresponds to class credits score):*	Class attendance	1	Research	0,5
	Project	2	Report	
	Colloquium	0,5	Seminar paper	
	Practical work		Oral exam	0,5
	Written exam		(Extra)	
Type of exam, grades and evaluation of students work during class and on final exam	Attending classes, active participation in lectures, project development, presentation of the project within the oral exam - PUBLIC HEARING SIMULATION.			

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Mandatory literature (available in the Library and via other media)	IAEA (2003): Radioactive Waste Management Glossary. IAEA, Vienna. IAEA (2011): Geological Disposal Facilities for Radioactive Waste, IAEA, Vienna. IAEA (2011): Geological Disposal Facilities for Radioactive Waste. IAEA Safety Standards, IAEA, Vienna. IAEA (2014): Near Surface Disposal Facilities for Radioactive Waste. IAEA Safety Standards, IAEA, Vienna.
Aditional literature (at the moment of study program proposition application)	BGS (2015): A Catalogue of Analogues for Radioactive Waste Management. BRITISH GEOLOGICAL SURVEY, COMMISSIONED REPORT CR/15/106. Eds. A.E. Milodowski, W.R. Alexander, J.M. West, R.P Shaw, F.M. McEvoy, J.M. Scheidegger and L.P. Field. Keyworth, Nottingham. Niels Walet (1999): Nuclear and Particle Physics. UMIST, Manchester. Basdevant, J.-L., Rich, J., Spiro, M. (2004): Fundamentals in Nuclear Physics from Nuclear Structure to Cosmology. Springer, New York. Pusch, R. (2008): Geological Storage of Highly Radioactive Waste, Springer, Verlag UCLA (1996): RADIATION SAFETY TRAINING MANUAL. UNIVERSITY OF CALIFORNIA, SAN FRANCISCO.
Examination terms	Every Thursday within exam-terms (at 10:00).
Other	

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