

1. GENERAL INFORMATION					
Study program title	Graduate study of Mining Engineering				
Course title	Tunneling		Semester	Winter	
Teacher	Asst. Prof. Vinko Škrlec, PhD		Course code	27055	
Course type	<input checked="" type="checkbox"/> obligatory <input type="checkbox"/> elective		ECTS	5,5	
Location	Faculty of Mining, Geology and Petroleum Engineering, Pierottijeva 6, Zagreb				
Language	<input type="checkbox"/> Croatian <input checked="" type="checkbox"/> English				
Class type	Weekly hours	Teaching staff	Office hours	Room	E-mail
Class	2	Asst. Prof. Vinko Škrlec, PhD	Every working day (10 a.m. – 2 p.m.).	V 223	vinko.skrlec@rgn.hr
Practice	2	Postdoctoral researcher Karolina Herceg, PhD	Every working day (10 a.m. – 2 p.m.).	V 503	karolina.gradiski@rgn.hr
Field lecture	0,5	Asst. Prof. Vinko Škrlec, PhD		V 223	vinko.skrlec@rgn.hr
		Postdoctoral researcher Karolina Herceg, PhD		V 503	karolina.gradiski@rgn.hr
learning level	1		Percentage of on-line class (max. 20%)	0	
2. COURSE DESCRIPTION					
Course aims	Obtaining theoretical and practical knowledge about rock, primary and secondary supporting system interaction, which in turn results in successful tunneling.				
Requirements for applicants					
Program level learning outcomes with course contribution	Understanding of basic terms in tunneling. Application of previously obtained knowledge from the fields of rock mechanics, soil mechanics and geology. Ability to set up and				

	independently solve calculation models. Independent analysis of results.
Expected course level learning outcomes (4-10 outcomes)	<p>Students will be able to:</p> <ul style="list-style-type: none"> - Explain and describe basic terms in tunneling (level 1) - Describe classical and modern tunnel excavation methods (level 2) - Describe the interaction between a rock and primary and secondary supporting system (level 4) - Calculate the stress near underground chamber opening (level 5) - Recommend excavation technology (level 7) - Plan and organize working area on a tunnel site (level 7) - Predict and solve any possible problems that can be presented during tunnel excavation (level 7)
Course contents by individual lessons	
Class	Practice
P1 – Introduction. Basic technical characteristics, historical overview and the future of tunneling. Types and functions of tunnels. Dimensions of tunnels, cross sections and longitudinal sections.	V1 – Boundary element method. Numerical modelling in tunneling. Example of tunnel excavation in Croatia.
P2 – Empirical approach to tunneling. Classical method of excavation by drilling and blasting using tunnel drill rigs.	V2 – Analysis of rock stress and strain. Example of tunnel excavation in Croatia.
P3 – Tunneling in hard rocks and tunneling in soft rocks or soils.	V3 – Working on class assignment. Example of tunnel excavation in Croatia.
P4 – Modern methods of tunnel excavation using excavators, road-headers and TBM.	V4 – Working on class assignment.
P5 – New Austrian tunneling method. Full-profile and multiphase excavations. Excavation method with one or more work faces. Categorization system and supporting system decisions.	V5 – Working on class assignment.
P6 – New Austrian tunneling method. Full-profile and multiphase excavations. Excavation method with one or more work	V6 – Class assignment delivery and analysis of solutions.

faces. Categorization system and supporting system decisions.				
P7 – Analysis of stress and strain near tunnel opening. Effect of excavation method on stress and strain.	V7 – Working on class assignment.			
P8 – Interaction of rock and primary supporting system. Elements of support system: anchors, shotcrete, wire mesh, steel ribs and lattice girder	V8 – Working on class assignment.			
P9 – Interaction of rock and primary supporting system. Elements of support system: anchors, shotcrete, wire mesh, steel ribs and lattice girder	V9 – Example of finite element method			
P10 – Soil strengthening methods, jet grouting, pipe roofing, retaining walls	V10 – Secondary support system, internal forces calculation and diagram of internal forces. Example.			
P11 – Construction of tunnels with a low overburden in urban areas.	V11 – Working on class assignment.			
P12 – Cut and cover method and Caisson method.	V12 – Working on class assignment.			
P13 – Hydro isolation of tunnels. Secondary supporting system, reinforced concrete lining.	V13 – Working on class assignment.			
P14 – Particularities of hydrotechnical HRT (Head Race tunnels), ensuring water tightness.	V14 – Class assignment delivery and analysis of solutions.			
P15 – Measuring equipment and details of tunnel shape measuring, rock and support system deformation measurements.	V15 – Class assignment delivery and analysis of solutions.			
Students' obligations	Regular class and practice attendance. Independent solving of class assignment within a given timeframe.			
Students' work track <i>(indicate share in ECTS points for each activity so that overall ECTS number corresponds to class credits score):</i>	Class attendance	2	Research	
	Project		Report	
	Colloquium		Seminar paper	1
	Practical work		Oral exam	1,5



	Written exam	1	(Extra)	
Type of exam, grades and evaluation of students work during class and on final exam	The knowledge is evaluated based on the assignments, preliminary exam and the final (written and oral) exam.			
Mandatory literature (available in the Library and via other media)	<ol style="list-style-type: none"> 1. Nova austrijska tunelska metoda, Rudarsko-geološko-naftni fakultet Zagreb, 2000 2. ITA: Konstruktivni projekt tunela, Zagreb 1992 3. Striegler: Tunnelbau, Muenchen 1993. 4. Frgić, L.: Tuneli, Rudarskogeološkonaftni fakultet, interna skripta, Zagreb 2012. 5. http://www.itaaites.org/ 6. http://www.transglobalhighway.com/ 7. http://home.no.net/lotsberg/index.html 8. http://www.tunnelonline.info/ 9. http://www.pipejacking.org/ 			
Additional literature (at the moment of study program proposition application)	<ol style="list-style-type: none"> 1. Whitacker, B.N., Frith, R.C.: Tunnelling, London 1990. 2. Popović, B.: Tuneli, Građevinska knjiga Beograd, 1987 3. Hoek, E., Kaiser, P.K., Bawden, W.F.: Support of Underground Excavation in Hard Rock, London, 2000. 4. Arhiva Zavoda: Projektna dokumentacija tunela 			
Examination terms	Every Monday within exam-terms (at 11 a.m.).			
Other				

