<table>
<tr><td colspan="2">NAME OF THE COURSE</td><td colspan="5">GROUNDWATER FLOW AND SOLUTE TRANSPORT MODELING</td></tr>
<tr><td>Code</td><td></td><td>Year of study</td><td colspan="4">1, II.semester</td></tr>
<tr><td>Course teacher</td><td>Hrvoje Gotovac, PhD, Assistant Professor</td><td>Credits (ECTS)</td><td colspan="4">5.0</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>E</td><td>F</td></tr>
<tr><td>30</td><td></td><td>15</td><td></td></tr>
<tr><td>Status of the course</td><td>Compulsory</td><td>Percentage of application of e-learning</td><td colspan="4">0%</td></tr>
<tr><td colspan="7">COURSE DESCRIPTION</td></tr>
<tr><td>Course objectives</td><td colspan="6">According to the labor market needs, the objectives of the course is to introduce basic theorethical and practical principles of groundwater flow and solute transport modeling as well as usage of classical solvers with finite element and finite difference methods.</td></tr>
<tr><td>Course enrolment requirements and entry competences required for the course</td><td colspan="6">Undergraduate qualification (6th level of EQF or CROQF) in the technical or natural sciences.</td></tr>
<tr><td>Learning outcomes expected at the level of the course (4 to 10 learning outcomes)</td><td colspan="6">The student will:
define the basic elements of the physical processes governing groundwater flow and solute transport,
define the conceptual flow and transport model,
define and use appropriate stochastic and/or numerical model using suitable computational techniques
learn state of tha art numerical and stochastic models
model and solve basic engineering flow and transport problems</td></tr>
<tr><td>Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="6">Part one: INTRODUCTION – Definition of confined and unconfined aquifers, generalized Darcy's law, heterogeneity of hydraulic conductivity, permeability and porosity measurements, description of the spatial parameters of aquifers. Stochastic description. Conceptual models.
Part two: FLOW MODELLING - Flow equation under saturated and non-saturated conditions, stationary and non-stationary conditions, defining initial and boundary conditions and model parameters. MODFLOW – centered block finite difference flow model. Fi-Flow – finite element flow model. Pumping tests.
Part three: TRANSPORT MODELLING - The principles of solute transport in aquifers, advective and dispersive transport, dispersion tensor, mass transfer. Euler finite element and difference transport models. Lagrangian transport models: a) MODPATH particle tracking algorithm for MODFLOW flow model, b) Random walk particle tracking algorithm for Fi-Flow model. Variable density flow and transport modelling (salt transport), reactive transport and multiphase flow (e.g. unsaturated flow water-air).
Part four: STOCHASTIC MODELLING – Uncertainty. Geostatistics – ordinary and indicator kriging. Small perturbation methods – the first order theory. Spectral methods. Monte-Carlo method. Tracer tests – example of MADE site.</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</td></tr>
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Student responsibilities	Preparation of an assignment.					
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	1.0	Research		Practical training	
	Experimental work		Report		(Other)	
	Essay		Seminar essay	1.0	(Other)	
	Tests		Oral exam	2.0	(Other)	
	Written exam	1.0	Project		(Other)	
Grading and evaluating student work in class and at the final exam	Three written assignments (40%), seminar (10%), final examination – oral (50%).					

	Title	**Number of copies in the library**	**Availability via other media**
Required literature (available in the library and via other media)	Zheng, C. and G. D., Bennet, Applied Contaminant transport modeling, John, Wiley and Sons, Inc., 2002		
	Gelhar, LW., Stochastic subsurface hydrology, Academic press, 1993.		
	Rubin, Y., Applied Stochastic Hydrogeoelogy, Oxford University Press, 2003.		
Optional literature (at the time of submission of study programme proposal)	H. Gotovac, R. Andričević, Internal materials (2012)		
Quality assurance methods that ensure the acquisition of exit competences	Quality assurance will be performed at three levels: (1) University level, through questionnaires; (2) Faculty level by Quality Control Committee; (3) Lecturer's level.		
Other (as the proposer wishes to add)			