Faculty of Civil Engineering / INFRASTRUCTURES / GROUNDWATER HYDRAULICS

Course:	GROUNDWATER HYDRAULICS			
Course ID	**Course status**	**Semester**	**ECTS credits**	**Lessons** (Lessons+Exercises+Laboratory)
11968	Mandatory	3	5	2+1+1
Programs	INFRASTRUCTURES			
Prerequisites	None.			
Aims	Knowledge acquisition from groundwater hydraulics.			
Learning outcomes	After having passed the exam, students will be able to: 1. Explan functioning of hydrogeological systems; 2. Explain parameters of porosous areas; 3. Understand equations of groundwater streaming; 4. Apply methods for solution of differential equations of groundwater streaming; 5. Create conceptual hydrogeological model; 6. Use MODFLOW-based softwares; 7. Develop a mathematical model of groundwater streaming			
Lecturer / Teaching assistant	Prof. Dr. Milan Radulović – lecturer			
Methodology	Lectures, exercises, tests, colloquiums.			
Plan and program of work				
Preparing week	Preparation and registration of the semester			
I week lectures	Introduction. Groundwater as part of water cycle. Structures of rocks porosity. Hydrogeological function of rocks masses. Recharge and discharge of aquifers. Examples from the territory of Montenegro			
I week exercises	Introduction. Groundwater as part of water cycle. Structures of rocks porosity. Hydrogeological function of rocks masses. Recharge and discharge of aquifers. Examples from the territory of Montenegro			
II week lectures	Aquifer parameters (hydraulic conductivity, porosity, groundwater velocity, hydraulic gradient, etc.). Darcy law. Heterogeneity and anisotropy of aquifer.			
II week exercises	Aquifer parameters (hydraulic conductivity, porosity, groundwater velocity, hydraulic gradient, etc.). Darcy law. Heterogeneity and anisotropy of aquifer.			
III week lectures	Groundwater flow through the saturated zone. Flow lines and flow mesh. Basic equatations of groundwater flow. Mass balance equatation. Generalization of Darcy law.			
III week exercises	Groundwater flow through the saturated zone. Flow lines and flow mesh. Basic equatations of groundwater flow. Mass balance equatation. Generalization of Darcy law.			
IV week lectures	Steady-state groundwater flow in the confined and unconfined aquifers.			
IV week exercises	Steady-state groundwater flow in the confined and unconfined aquifers.			
V week lectures	Transient groundwater flow in the confined and unconfined aquifers.			
V week exercises	Transient groundwater flow in the confined and unconfined aquifers.			
VI week lectures	Methods for solving the differential equitation of groundwater flow.			
VI week exercises	Methods for solving the differential equitation of groundwater flow.			
VII week lectures	I TEST, I COLLOQUIUM			
VII week exercises	I TEST, I COLLOQUIUM			
VIII week lectures	Numerical models. Transfer of the conceptual model to the numerical model. MODFLOW. Geometry of groundwater model. Parameters of groundwater model.			
VIII week exercises	Numerical models. Transfer of the conceptual model to the numerical model. MODFLOW. Geometry of groundwater model. Parameters of groundwater model.			
IX week lectures	Boundary conditions. Calibration of groundwater model. Sensitivity analysis. Verification of model.			
IX week exercises	Boundary conditions. Calibration of groundwater model. Sensitivity analysis. Verification of model.			
X week lectures	Groundwater flow to the well. Pumping test data processing.			
X week exercises	Groundwater flow to the well. Pumping test data processing.			

XI week lectures	Groundwater flow in the karst aquifer. Limits of Darcy law in the karst aquifers.
XI week exercises	Groundwater flow in the karst aquifer. Limits of Darcy law in the karst aquifers.
XII week lectures	Field investigation works. Groundwater flow through and under dams and embankments.
XII week exercises	Field investigation works. Groundwater flow through and under the dams and embankments.
XIII week lectures	Groundwater inflow to the tunnels and excavations.
XIII week exercises	Groundwater inflow to the tunnels and excavations.
XIV week lectures	II TEST, II COLLOQUIUM
XIV week exercises	II TEST, II COLLOQUIUM
XV week lectures	Repetition of lessons.
XV week exercises	Repetition of lessons.
Student workload	Weekly 3.0 credits x 40/30 = 4 hours Total workload for the Subject 3.0x30 = 90 hours

Per week	**Per semester**
5 credits x 40/30=6 hours and 40 minuts 2 sat(a) theoretical classes 1 sat(a) practical classes 1 excercises **2 hour(s) i 40 minuts** of independent work, including consultations	Classes and final exam: **6 hour(s) i 40 minuts x 16 =106 hour(s) i 40 minuts** Necessary preparation before the beginning of the semester (administration, registration, certification): **6 hour(s) i 40 minuts x 2 =13 hour(s) i 20 minuts** Total workload for the subject: **5 x 30=150 hour(s)** Additional work for exam preparation in the preparing exam period, including taking the remedial exam from 0 to 30 hours (remaining time from the first two items to the total load for the item) **30 hour(s) i 0 minuts** Workload structure: **106 hour(s) i 40 minuts (cources), 13 hour(s) i 20 minuts (preparation), 30 hour(s) i 0 minuts (additional work)**
Student obligations	Attendance, preparation of graphical papers, taking the tests.
Consultations	Monday, 12.00 - 13.00
Literature	Pušić M. (1994) Hidraulika podzemnih voda. Slavija press, Novi Sad Pušić M. (2003) Dinamika podzemnih voda. Rudarsko-geološki fakultet, Beograd Mandle R. J. (2002) Groundwater modeling guidance. Michigan department of environmental quality.
Examination methods	- Attendance to lectures and exercises: max 4 pt; - Graphic works: max 4 pt; - Seminary Essays: max 10 pt; - Tests: max 12 pt; - Colloquiums: max 40 pt; - Final exam: max 30 pt; - Pass requires minimum 50 pt.
Special remarks	
Comment	Further information about the Subject can be required from the lecturer/assistant, head of the study program and vice dean of academic affairs

Grade:	F	E	D	C	B	A
Number of points	less than 50 points	greater than or equal to 50 points and less than 60 points	greater than or equal to 60 points and less than 70 points	greater than or equal to 70 points and less than 80 points	greater than or equal to 80 points and less than 90 points	greater than or equal to 90 points