GRAĐEVINSKI FAKULTET

Course title	**GROUNDWATER FLOW AND TRANSPORT MODELLING**			Course code	DHID08
Study programme Cycle	University graduate study, programmes: Hydraulic and Environmental Engineering and General 2nd cycle			Study year	second
ECTS credit value:	5	Semester	third	Hours per semester (l+e+s)	30+30
Course status:	mandatory/ elective	Prerequisites:	First cycle	Corequisites:	none
Access to the course:	Students of the first year of the University Graduate Study, Hydraulic and Environmental Engineering programme			Class schedule:	According to schedule

Course holder/teacher:	Mirna Raič, Ph.D.
Contact hours/consultations:	will be published on the web page of the course for each academic year.
E-mail address and phone number:	mirna.raic@gf.sum.ba; 036 355 020
Assistant	-
Contact hours/consultations:	-
E-mail address and phone number:	-
Course objectives:	· Present to students and describe the theoretical foundations of groundwater formation, characteristics of porous medium and basic equations of groundwater flow, · Introduce students into possible typical problems related to groundwater flow and methods for solving them, · Acquiring basic knowledge on calculation of hydrodynamic processes in underground flows, · Inform students about the possibilities of using some software programmes in the field of basic hydraulic calculations in underground flows.
Learning outcomes (general and specific competences):	After successful completion of the course, the student will be able to: · master the basic elements of physical processes defining groundwater flows. · define the flow problem from its physical statement, conceptual model to the final stochastic and/or numerical model using appropriate techniques for solving them. · master the basic commercial software programmes used in teaching.
Brief syllabus content:	Potential groundwater flow; Filtration with free surface; Flow equation, steady and unsteady conditions; Mathematical modelling of flow and presentation of appropriate numerical methods; Defining initial and boundary conditions and model parameters; Pumping tests; Introduction to the DHI WASY FEFLOW software suite; Karst hydraulics; Principles of material transport in aquifers; Mathematical modelling of transport, numerical and analytical models, defining initial and boundary conditions and model parameters; Using the DHI WASY FEFLOW software suite; Application of flow and pollution transport models on a practical example. Results interpretation method and uncertainty analysis, assessment and analysis of risks due to groundwater pollution.

Instruction method (mark in bold)	**lectures**	**exercises**	seminars	**individual assignments**

	consultations/tutorials	mentoring	**field instruction**	Other: seminar paper
	Notes: *All classes (exercises and lectures) are held in the classroom.* At least one visit to some of the hydroelectric power plants, as well as laboratory and/or field exercises, are planned as part of the teaching.			
Student obligations	- *all enrolled students should register in the SUMARUM system* - attend classes and participate in the teaching process, - prepare and defend the programme work			
Student monitoring and evaluation (mark in bold)	**Class attendance**	**Activities in classes**	Seminar paper	Practical work
	Oral exam	Written exam	Preliminary exams (continuous assessment)	**Programme work**

Detailed description of evaluation within the European Credit Transfer System

STUDENT OBLIGATIONS	HOURS (ESTIMATE)	SHARE IN ECTS	SHARE IN GRADE
Class attendance	**45***	**1.5**	**10%**
Programme work - written part	**60**	**2.0**	**45%**
Oral exam: presentation and defence of the programme work	**45**	**1.5**	**45%**
Make-up exam			
Oral part	45	1.5	45%

*pursuant to Article 60 of the Study Rules, September 2018

Additional explanations:

Requirement for admission to make-up oral exam: preparation and submission of the programme work

In the event that the student does not complete or defend the programme assignment in the current academic year, he or she shall register the course again in the next academic year and receive a new assignment.

According to Study Rules, the final grade is obtained as follows:
0 - 55% insufficient (1)
56 - 66% sufficient (2)
67 - 78% good (3)
79 - 90% very good (4)
91 - 100% excellent (5).

Mandatory reading:	(1) Bear, J., Verruijt, A., Modeling groundwater flow and pollution (Theory and applications of transport in porous media), Reidel Publ., Holland, 1987. (2) Diersch, H.-J. G., FEFLOW: Finite Element Modeling of Flow, Mass and Heat Transport in Porous and Fractured Media, Springer Heidelberg, 2014. (3) Kinzelbach, W., Groundwater Modelling - An Introduction with Sample Programs in BASIC, Elsevier, Amsterdam, Oxford, New York, Tokyo, 1986. (4) Jović, V., Osnove hidromehanike, Element, Zagreb, 2006. (5) Wang, H. F., Anderson, M. P., Introduction to Groundwater Modeling – Finite Difference and Finite Element Methods, W. H. Freeman and Co., San Francisco, 1982.

Supplementary reading:	Selected materials: professional studies and published papers in the field of hydrodynamics and/or groundwater flow and transport modelling on the recommendation of the subject professor.
Additional course information	The course is held in Croatian and English

Course title	**STRUCTURAL ANALYSIS II**				*Course code*	**PMEH06**	
Study programme Cycle	**University Undergraduate Study of Civil Engineering, 1st cycle**				*Study year*	**2nd (second)**	
ECTS credit value:	**6.0**	*Semester*	**4th (summer)**		*Hours per semester (l+e+s)*	**45+30+0**	
Course status:	**Mandatory**	*Prerequisites:*	None	*Corequisites:*	None		
Access to the course:	Students of the second year of University Undergraduate Study of Civil Engineering			*Class schedule:*	According to schedule		
Course holder/teacher:	Vlaho Akmadžić, Ph.D.						
Contact hours/consultations:	According to the consultation schedule and as agreed						
E-mail address and phone number:	vlaho.akmadzic@gf.sum.ba, +387 36 355 027						
Assistant	Željko Mikulić, senior assistant						
Contact hours/consultations:	According to the consultation schedule and as agreed						
E-mail address and phone number:	zeljko.mikulic@gf.sum.ba						
Course objectives:	To introduce students into the deformability of linear members (longitudinal, shear, bending and twisting). Acquiring basic knowledge of statically indeterminate beam girders, frames, grids and arches. Introduction to force method on deep beams. Introduction to displacement method on deep beams. Analysis of simple beam and continuous girders, and 2D and 3D frames with stiff crossbars. Then, analysing more complex systems, specifically 2D and 3D general frame girders and arches, and space girders and grids. Introduction to fundamentals of modelling of linear structures with FEM, boundary conditions and internal releases. Determination of internal forces, displacements and deformation curves. Introduction to loading schemes, envelopes and influence lines in complex systems. Introduction to iterative methods. Analysis of bending of thin plates with the use of FEM (simple and continuous plates of simple boundary conditions with and without openings), and girders and plates on an elastic base. Defining wall systems (independent wall, deep beam, walls with openings) and modelling possibilities. Modelling of complex plates and roof structures with flat surfaces. Introduction to complex building structures with columns, plates and load-bearing walls, as well as the concepts of floor stiffness centre and mass centre. Numerical models. Introduction to failures of static modelling and computer use.						
Learning outcomes (general and specific competences):	To be familiar with calculation methods of statically indeterminate systems and to have acquired knowledge of the ways of their functioning. To define, analyse and calculate the statics of primarily linear, and through modelling also of plate structures, as well as walls and deep beams.						
Brief syllabus content:	Types of deformability of linear members, longitudinal, shear, bending and twisting. Statically indeterminate beam girders, frames, grids and arches. Force method and displacement method on deep beams in plane. Use of FEM, stiffness matrix and full fixity force. Influence of temperature effect. Simple and continuous beam girders. Plane and space frames with stiff crossbars. General plane and space frames. Arch girders in plane and space. Grids. Modelling of linear structures with FEM, boundary conditions and internal releases. Internal forces, displacements and deformation curves. Loading schemes, envelope and influence lines. Iterative methods. Introduction to mixed method. Basics of thin plates bending. Use of FEM. Continuous plates with						

	simple boundary conditions. Loading schemes. Girder and plate on an elastic base. Basics of walls and deep beams. Use of FEM. Independent wall and deep beam. Walls with openings. Modelling of walls with linear elements. Modelling of complex plates. Roof structures with flat surfaces. Complex building structures with columns, plates and load-bearing walls. Floor stiffness centre. Loading schemes. Numerical models. Failures of static modelling and computer use.			
Instruction method (mark in bold)	**lectures**	**exercises**	seminars	individual assignments
	consultations/tutorials	mentoring	field instruction	other
	Remarks: *Classes are held by the combined model. Exercises are performed in the classroom and lectures at distance.*			
Student obligations	- Regular attendance of classes, preparation of individual assignments, partial test and final test, and for students unsuccessful in tests, it is mandatory to take make-up written and oral exam. - *registration to e-course on the SUMARUM platform*			
Student monitoring and evaluation (mark in bold)	**Class attendance**	**Activities in classes**	**Seminar paper**	Practical work
	(Oral exam)	***(Written exam)***	**Continuous assessment**	Essay

Detailed description of evaluation within the European Credit Transfer System

STUDENT OBLIGATIONS	HOURS (ESTIMATE)	SHARE IN ECTS	SHARE IN GRADE
Attendance of classes and in-class activities	**56***	**1.8**	**10%**
Continuous assessment	**126**	**4.2**	**90%**
1st assessment	60	2.00	40%
2nd assessment	63	2.10	50%
(Make-up exam)	**126**	**4.2**	**90%**
Written exam	54	1.8	40%
Oral exam	66	2.2	50%

*pursuant to Article 60 of the Study Rules, September 2018, 1 teaching hour=3/4 hours and 1 ECTS=30 hours.

A maximum of 100 points can be achieved for each of the specified activities.
For each specified activity, the minimum required number of points is 55, except for the minimum number of points for attending classes. Mandatory attendance is 80% (equivalent to 80 points).
Assessments are held in the 9th and 15th week of classes.
The number of points earned for each individual activity participates in the total number of points in the percentage specified in the previous table, and the final grade is obtained based on the total number of points:
55 - 66 points sufficient (2)
67 - 78 points good (3)
79 - 90 very good (4)
91 - 100 points excellent (5).
Students who do not achieve at least the minimum required number of points in the test or are dissatisfied with the number of points achieved take the make-up exam.
The number of points achieved in the written and oral exams participates in the total number of points in the percentage specified in the previous table, and the final grade is obtained analogously to the previous one.

Mandatory reading:	(1) Mihanović, A., Trogrlić, B., Akmadžić, V.: *Građevna statika II*, Građevinsko-arhitektonski fakultet Split, Split, 2014. (2) Akmadžić, V., Trogrlić, B., Prusac K.: *Građevna statika II – metoda sila kroz primjere*, Sveučilište u Mostaru, Mostar, 2016.
Supplementary reading:	(1) Akmadžić, V., Smoljanović, H., Balić I.: *Građevna statika II – metoda pomaka kroz primjere*, Sveučilište u Mostaru, Mostar, 2018. (2) Anđelić M.: *Statika neodređenih štapnih konstrukcija*, Društvo hrvatskih građevinskih konstruktora, Zagreb, 1993. (3) Timoshenko S.P. and D.H. Young, *Theory of Structures*, McGraw-Hill, New York, 1988.
Additional course information	*The course is held in Croatian and English*

ANNEX: Course schedule

Teaching unit number	TOPICS AND READING
I.	Title: Types of deformability of linear members
	Short description: Basics of states, principles and theorems. Emphasis is placed on the fundamentals of deformability of linear members. Longitudinal, shear, bending and twisting.
	Reading: Mihanović A., Trogrlić B., Akmadžić V.; Akmadžić V., Trogrlić B., Prusac K.
II.	Title: Introduction to force method
	Short description: Calculation procedure (determining DSI, cancelling redundant external and internal connections, forming a system of compatibility equations, procedure of determining internal forces diagrams).
	Reading: Akmadžić V., Trogrlić B., Prusac K.
III.	Title: Force method - continued
	Short description: Using the principles of symmetry and antisymmetry. Taking into account different cross sections. Cases when, in addition to moments, normal force is also taken into account.
	Reading: Akmadžić V., Trogrlić B., Prusac K.
IV.	Title: Force method - continued
	Short description: Settlement of supports. Temperature effects. Continuous girders. Elastic centre of gravity and elastic support.
	Reading: Akmadžić V., Trogrlić B., Prusac K.
V.	Title: Full displacement method
	Short description: Introduction to full displacement method, stiffness matrices for FEM.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.; Akmadžić V., Smoljanović H., Balić I.
VI.	Title: Full displacement method - continued
	Short description: State of full fixity, state of unit displacements, informatively about the concept of mapping, special boundary conditions, movable and immovable systems.
	Reading: Mihanović, A., Trogrlić, B., Akmadžić, V.
VII.	Title: Full displacement method - continued
	Short description: Final about full displacement method. Familiarisation with the technical displacement method (unknowns, sign convention, fixed and movable supports, equilibrium equations, cantilevers and overhangs) and controls.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.; Akmadžić V., Smoljanović H., Balić I.
VIII.	Title: Full displacement method - continued
	Short description: Final about technical displacement method. Introduction to mixed method.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.; Akmadžić V., Smoljanović H., Balić I.
IX.	Title: Calculation of frame with rigid crossbars and more complex examples

	Short description: Presenting the functioning of full displacement method on the calculation of a frame with rigid crossbars. Also, presentation of the method on more complex 2D and 3D systems.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.; Akmadžić V., Smoljanović H., Balić I.
X.	Title: Iterative methods
	Short description: Review of iterative calculation methods with emphasis on the Cross iterative procedure.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.
XI.	Title: Grids and frames
	Short description: Introduction to grid systems (soft and rigid). Analysis of symmetric and asymmetric frames. The concepts of geometric floor centre, mass centre, and stiffness centre. Loading schemes. Modelling.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.
XII.	Title: Fundamentals of thin plates bending.
	Short description: Introduction to fundamentals of thin plate theory. Use of FEM. Continuous plates with simple boundary conditions. Loading schemes. Girder and plate on an elastic base.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.
XIII.	Title: Basics of walls and deep beams.
	Short description: Use of FEM. Independent wall and deep beam. Walls with openings. Possibility of wall modelling with linear elements.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.
XIV.	Title: More complex static systems
	Short description: Modelling of complex plates. Roof structures with flat surfaces. Complex building structures with columns, plates and load-bearing walls.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.
XV.	Title: Failures of static modelling and computer use.
	Final about modelling of simple and complex structures and failures of static modelling and computer use.
	Reading: Mihanović A., Trogrlić B., Akmadžić, V.