Federal State Autonomous Educational Institution for Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
NAMED AFTER PATRICE LUMUMBA
(RUDN University)

Academy of Engineering
(name of the educational division - developer of the HEP HE)

COURSE SYLLABUS

Applied Groundwater Modeling
(Subject / Course title)

Recommended by the Didactic Council for the Education Field of:

05.04.01 Geology
(code and name of the Higher Education Field)

The development of the discipline is carried out within the framework of the implementation of the Higher Education Programme of Higher Education (HEP HE):

Mining Geology
(name (profile/specialization) of the Higher Education Program)

2023

1. AIMS AND OBJECTIVES

The purpose of mastering the discipline "Applied Groundwater Modeling" is acquiring knowledge, skills and experience in the field of is to provide students with sufficient training in the fundamental theory and application of groundwater modeling to be able to develop the skill sets required to tackle basic environmental problems that are commonly addressed via flow and solute transport modeling, characterizing the stages of competence formation and ensuring the achievement of the planned results of the educational programme.

The focus of this course will be on applying a suite of different hydrogeological modeling methods to examine flow and transport processes in the Earth and to be able to appropriately evaluate limitations of the model. The major task in this course will be the "Modeling Project" whereby you will progressively work on the construction of a flow and transport model from the consultant's point of view.

2. REQUIREMENTS TO LEARNING OUTCOMES

Mastering the discipline "Applied Groundwater Modeling" is aimed at developing the following competencies (parts of competencies) among students:

Table 2.1. The list of competencies formed by students in the course of mastering the discipline (the results of mastering the discipline)

Code	Competence	Competence Formation Indicators (within this discipline)
GC-2	Able to manage a project at all stages of its life cycle	GC-2.1. Formulates a problem whose solution is directly related to the achievement of the project goal; GC-2.2 Identifies the connections between the tasks and the expected results of their solution; GC-2.3 Identifies the available resources and constraints within the assigned tasks and the applicable legal regulations.
GPK-2	Able of independently formulating the research objectives and establishing a sequence for resolving professional problems.	GPC-2.1. Knows the basics and methods of organizing research activities, methods of setting goals and methods of achieving them; GPC-2.2. is able to develop research methods; GPC-2.3. has methods of establishing cause-effect relationships and identifying the most significant among them and skills of independent formulation of research objectives.
PC-3.	Capable of projecting, implementing, and managing a hydrogeological study of the territory during the exploration and development of a mineral deposit.	PC-3.1 Know the theoretical foundations and methods of hydrogeological study of the territory at the stage of exploration and development of mineral deposits; PC-3.2 Be able to apply methodological solutions in the design, implementation and management of hydrogeological study of the territory at the stage of exploration and development of mineral deposits; PC-3.3 Be able to apply the knowledge and skills obtained in the design, implementation and management of the hydrogeological study of the territory at the stage of exploration and development of mineral deposits.

3. THE PLACE OF DISCIPLINE IN THE STRUCTURE OF HEP HE

Discipline "Applied Groundwater Modeling" refers to the University Disciplines Module of block B1 of the HEP HE.

As part of the HEP HE, students also master other disciplines and / or practices that contribute to the achievement of the planned results of mastering the discipline "Applied Groundwater Modeling".

Table 3.1. The list of components of the HEP HE that contribute to the achievement of the planned results of the development of the discipline

Code	Competence	Previous Disciplines (Modules)*	Subsequent Disciplines (Modules)*
GC-2	Able to manage a project at all stages of its life cycle	Modelling of Mineral Deposits	Final State Attestation
GPK-2	Able of independently formulating the research objectives and establishing a sequence for resolving professional problems.	Modelling of Mineral Deposits; Geological and Geophysical Basics of Mineral Prospecting and Exploration;	Research Work (Mining Geology). Part 2; Research Work (Geological and Geophysical Survey). Part 2; Final State Attestation
PC-3.	Capable of projecting, implementing, and managing a hydrogeological study of the territory during the exploration and development of a mineral deposit.	*Mineralogy;* Mining Geology;	Pre-graduation Practical Training; Research Work (Mining Geology). Part 2; Final State Attestation

* - filled in in accordance with the matrix of competencies and academic curriculum of HEP HE

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

Course workload "Applied Groundwater Modeling" is 4 credit units.

Table 4.1. Types of academic activities during the period of the HE programme mastering

Type of academic activities		TOTAL, ac. hrs.	Semester 3
Contact academic hours		*36*	*36*
Lectures		18	18
Lab work		-	-
Seminars (workshops/tutorials)		18	18
Self-study (ies), academic hours		*90*	*90*
Evaluation and assessment (exam or pass/fail grading)		*18*	*18 Exam*
Course workload	academic hours	**144**	**144**
	credits	**4**	**4**

5. COURSE MODULES AND CONTENTS

Table 5.1. Course Modules and Contents by types of academic activities

Modules	Topics	Type of academic activities*
Module 1. Principles and Procedures of Numerical Simulation	Topic 1.1. Introduction to Numerical Simulation	Lec, Sem
	Topic 1.2. Hydrodynamic Groundwater Calculations	Lec, Sem
	Topic 1.3. Theoretical framework of computer simulation in hydrogeology	Lec, Sem
Module 2. Seepage and Groundwater Flow	Topic 2.1. Types of Groundwater flow	Lec, Sem
	Topic 2.2. Spatial discretization groundwater flow	Lec, Sem
Module 3. Numerical simulation of groundwater system	Topic 3.1. Hydrogeological conceptual model development	Lec, Sem
	Topic 3.2. Calibration Hydrodynamic model	Lec, Sem
	Topic 3.3. Predictive Modeling and Validation	Lec, Sem

* - *Lec – Lectures; Lab – Lab work; Sem – Seminars (workshops/tutorials).*

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom Equipment and Technology Support Requirements

Classroom for Academic Activity Type	Classroom Equipment	Specialized educational / laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	Auditorium for lecture-type classes, equipped with a set of specialized furniture; blackboard (screen) and technical a set of specialized furniture, a board (screen), and technical means of multimedia presentations.	
Computer Lab	Computer lab for conducting classes, group and individual consultations, current control and intermediate attestation, equipped with personal computers (10 pcs. computer class equipped with 21 personal computers, a blackboard (screen) and multimedia devices. technical means of multimedia presentations.	Specialized software: • Processing MODFLOW, • Surfer (or QGIS)
Seminars	Auditorium for classes seminars, group and individual consultations, current control and intermediate attestation, equipped with a set of a set of specialized furniture and	

	technical means of multimedia presentations.	
Self-studies	Auditorium for independent work (can be used for seminars and consultations), equipped with a set of a set of specialized furniture and computers with access to the EITS of the university.	

7. RECOMMENDED SOURCES FOR COURSE STUDIES

Main reading(sources):

1. Sanderson D.J., Zhang X., Numerical modelling and analysis of fluid flow and deformation of fractured rock masses, Elsevier, 2002 г., 300 стр., ISBN: 0-08-043931-4, https://www.geokniga.org/books/30770
2. Fetter C.W., Applied hydrogeology / Прикладная гидрогеология, Waveland Press, 2018, 621p., , ISBN: 1-4786-3709-9, https://www.geokniga.org/books/31204
3. Merkel B.J., Planer-Friedrich B., Groundwater geochemistry. A practical guide to modeling of natural and contaminated aquatic systems, Springer, 2005 г., 206 стр., ISBN: 3-540-24195-7, https://www.geokniga.org/books/24600
4. Bloetscher F. Manual of water supply practices. Groundwater, American Water Works Association, 2014 г., 295 стр., ISBN: 978-1-58321-964-5, https://www.geokniga.org/books/31486

Additional (optional) reading (sources):

1. Schmid, Wolfgang, and Hanson, R.T., 2009, The Farm Process Version 2 (FMP2) for MODFLOW-2005—Modifications and Upgrades to FMP1: U.S. Geological Survey Techniques and Methods 6-A-32, 102 p. https://pubs.usgs.gov/tm/tm6a32/pdf/tm6a32.pdf
2. USGS Publications Warehouse, https://pubs.er.usgs.gov/
3. United states Environmental Protection Agency (EPA), https://www.epa.gov/

Additional reading (without public access):

1. Mary P. Anderson, William W. Woessner and Randall J. Hunt Book Applied Groundwater Modeling (Second Edition), Academic Press, 2015, Page iv, ISBN 9780120581030, https://doi.org/10.1016/B978-0-08-091638-5.00019-5
2. J.P. Brandenburg Geologic Frameworks for Groundwater Flow Models 2020 https://doi.org/10.21083/978-1-7770541-9-9
3. Hill, Mary C. (Mary Catherine) Effective groundwater model calibration: with analysis of data, sensitivities, predictions, and uncertainty/Mary C. Hill, Claire R. Tiedeman.
4. Bakker, M., & Post, V. (2022). Analytical Groundwater Modeling: Theory and Applications using Python (1st ed.). CRC Press. https://doi.org/10.1201/9781315206134

5. Konikow, L.F., Hornberger, G.Z., Halford, K.J., and Hanson, R.T., 2009, Revised multi-node well (MNW2) package for MODFLOW ground-water flow model: U.S. Geological Survey Techniques and Methods 6–A30, 67 p.

6. Poeter, Eileen Graphical Construction of Groundwater Flow Nets / Eileen Poeter and Paul Hsieh - Guelph, Ontario, Canada, 2020. 67 p.

Internet-(based) sources:

1. Electronic libraries with access for RUDN students:
- RUDN Electronic Library System – RUDN ELS http://lib.rudn.ru/MegaPro/Web
- ELS "University Library Online" http://www.biblioclub.ru
- ELS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- ELS "Lan" http://e.lanbook.com/
- ELS "Trinity Bridge" http://www.trmost.ru

2. Databases and search engines:
- Electronic Fund of Legal and Normative-technical Documentation http://docs.cntd.ru/
- Yandex search engine https://www.yandex.ru/
- Google search engine https://www.google.ru/
- abstract database SCOPUS http://www.elsevierscience.ru/products/scopus/

*Learning toolkits for self- studies in the RUDN LMS TUIS *:*

1. Guidelines for students on the development of the subject "Applied Groundwater Modeling".
2. Course of lectures on the subject "Applied Groundwater Modeling".

* - all educational and methodological materials for independent work of students are placed in accordance with the current procedure on the page of the subject **in LMS TUIS**!

8. ASSESSMENT AND EVALUATION TOOLKIT AND GRADING CRITERIA

Assessment and Evaluation Toolkit (AET), Grading System (GS)* for assessing the level of competence (part of competence) for the subject "Applied Groundwater Modeling" are presented in the Appendix to the Course Syllabus of the subject.

* - AET and GS are formed on the basis of the requirements of the relevant local normative act of the RUDN University.

DEVELOPERS:

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