7.9 CE0723 - Groundwater Hydraulics

(1) GENERAL

SCHOOL	ENGINEERING SCHOOL		
ACADEMIC UNIT	CIVIL ENGINEERING DEPARTMENT		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**CE0723**	**SEMESTER**	**7**
COURSE TITLE	**Groundwater Hydraulics**		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	3	5
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).	**3**	**5**

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialisation Course
PREREQUISITE COURSES:	Fluid Mechanics (CE0430) Hydraulics (CE0520) English level B2 or higher is required for Erasmus incoming students
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek (English/Erasmus)
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes
COURSE WEBSITE (URL)	https://eclass.uniwa.gr/courses/CIV204/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to give the students fundamental concepts of the basic elements of development and application of numerical models in the scientific field of Groundwater Hydraulics. Of particular importance is the knowledge of the scope and the necessary parameters that must be included in such a numerical model.

Upon completion of the course, students will have:

1. To formulate the equations that describe specific problems of Groundwater Hydraulics.
2. To know the basic methods of solving the equations of Groundwater Hydraulics.
3. To know the mechanisms of interaction between surface and underground aquifers.
4. To know the principles of hydraulic design and operation of wells

5. To know the mechanisms of pollutant transport in groundwater.
6. To know the basic methods of decontamination of underground aquifers.
7. To assess the environmental impact of the exploitation of groundwater resources.
8. To select the appropriate method of decontamination of a contaminated underground aquifer.
9. To participate in water resources management projects.

Specifically, students will be able to:

1. Have adequate comprehension skills of groundwater hydraulics problems
2. Evaluate the problems of groundwater flow
3. Manage time in an appropriate manner.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?;.

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*

Specifically, students will be able to perform:

- Search for, analysis of, and synthesis of data and information, implementing appropriate technologies.
- Independent work - Team work - Working in an international / interdisciplinary environment.
- Decision-making
- Proact free, creative and inductive thinking

(3) SYLLABUS

1. Introduction. Fundamental concepts of introductory concepts and definitions (permeability, hydraulic conductivity, storage, hydraulic heights and gradient, homogeneity, anisotropy, etc.).
2. Hydraulic aquifer characteristics. Classification and characteristics of aquifers.
3. The hydrological cycle and the water balance.
4. Basic steady flow equations. Darcy's law and the equation of continuity.
5. Initial and boundary conditions. Dupuit assumption.
6. One-dimensional flow equations in confined, unconfined and leaky aquifers.
7. Detailed solutions to one-dimensional flow problems in porous media.
8. Steady and no steady flows to ditches and wells (at confined, unconfined and leaky aquifers).
9. Multiple well systems. Effect of boundary conditions. The method images.
10. Two-dimensional flow equations in unconfined, leaky, and confinedc aquifers.
11. Saltwater Intrusion in coastal aquifers (salinity). Differential equations of coastal aquifer salinization. The Ghyben-Herzberg equation.
12. Artificial enrichment of aquifers.
13. Groundwater pollution. Sources of Pollution, Mechanisms of pollutant transport (advection, dispersion, adsorption, chemical conversion).
14. Differential equations of advection and dispersion of conservative and non-conservative pollutants.
15. Laws of interaction between pollutants and porosity. Equations and analytical solutions.
16. Decontamination technologies and rehabilitation of contaminated aquifers.
17. In-situ, ex-situ and on-site technologies. Hydraulic and thermal methods. Basic design features.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face in-class teaching. When needed, distance teaching (synchronous/asynchronous)
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Use of I.C.T. in Teaching and Student Communication
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non- directed study according to the principles of the ECTS*	
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open- ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	The examination is in Greek for resident students. Erasmus students are examined in English. Final written examination (2.5 hours): 60% (Problem- solving, multiple choice test, questions with short answers) Weekly home assignments and/or semester long project: 40% The exam layout is explained to the students well before the examination; weights per subject /exercise are explicitly indicated on the exam form. Examination results (including total grade and grade per subject) are posted on the course e-class site. Students can have access to their exam scripts on request; they may ask for clarifications on mistakes, grading etc.

Activity	***Semester workload***
Lectures	39
Classwork	51
Preparation for Project	30
Personal Study	30
Course total	**150**

(5) ATTACHED BIBLIOGRAPHY

Greek Bibliography:

1. Antonopoulos, V. (2001), Groundwater Quality and Pollution, ZITI Publications (in Greek). ISBN: 9604316834.
2. Gidarakos, E. and Aivalioti, M. (2005), Soil and Groundwater Rehabilitation Technologies from Dangerous Pollutants, ZIGOS Publications (in Greek). ISBN: 9608065526.
3. Karamouzis, N. D. (2014), Hydraulics and Management of Groundwater, GRAFIMA Publications (in Greek). ISBN: 97896068657702.
4. Latinopoulos, P. (2006), Groundwater Hydraulics, CHARIS EPE Publications.
5. Soulios, Ch. G., (2010), General Hydrogeology - Volume A: Surface hydrology, storage and distribution of groundwater, groundwater flows, UNIVERSITY STUDIO PRESS (in Greek). ISBN: 9789601219035.
6. Soulios, Ch. G., (2012), General Hydrogeology - Volume B: Groundwater flow to pumping projects, construction of pumping projects, UNIVERSITY STUDIO PRESS (in Greek). ISBN: 9789601222172.
7. Soulios, Ch. G., (2012), General Hydrogeology - Volume D: Groundwater quality, groundwater pollution, UNIVERSITY STUDIO PRESS (in Greek). ISBN: 9601215336.
8. Terzidis, A. G. and Karamouzis, N. D. (2001), Groundwater Hydraulics, ZITI Publications (in Greek). ISBN: 9604316532.
9. Tolikas, K. D. (2005), Τολίκας Κ. Δημήτριος, Groundwater Hydraulics, EPIKENTRO Publications. ISBN: 9608873177.
10. Voudouris, S. K. (2014), Technical Hydrogeology. Underground water, TZIOLAS Publications (in Greek). ISBN: 9789604184071.
11. Voudouris, S. K. (2015), Environmental Hydrogeology: Groundwater and Environment, TZIOLAS Publications (in Greek). ISBN: 9789604181704.

12. Voudouris, S. K. (2015), Groundwater Exploitation and Management, TZIOLAS Publications (in Greek). ISBN: 9789604184699.

Foreign Bibliography:

1. Anderson, M. P., Woessner, W. W., and Hunt, R. J. (2015), Applied groundwater modeling: simulation of flow and advective transport. Academic press. ISBN 978-0-12-058103-0.
2. Bear, J. (1972), Dynamics of fluids in porous media. Dover Publications, Inc. ISBN 978-0-486-65675-5.
3. Bear, J. (2007), Hydraulics of groundwater. Dover Publications, Inc. ISBN 978-048-645-355-2.
4. Bear, J., and Cheng, A. H. D. (2010), Modeling groundwater flow and contaminant transport (Vol. 23). Dordrecht: Springer.e-ISBN 978-1-4020-6682-5.
5. Charbeneau, R. J. (2010), Groundwater hydraulics and pollutant transport. Prentice Hall. ISBN 0-13-975616-7.
6. Chiang, W. H. (2005), 3D-Groundwater modeling with PMWIN: a simulation system for modeling groundwater flow and transport processes. Springer Science & Business Media. e-ISBN 978-3-540-27592-3.
7. Coutelieris, F. A. and Delgado, J.M.P.Q. (2012), Transport Processes in Porous Media, Springer-Verlag Berlin Heidelberg. e-ISBN 9783642279102.
8. De Smedt, F., and Zijl, W. (2017), Two-and three-dimensional flow of groundwater. CRC Press., ISBN 978-1-138-57888-3..
9. Delgado, J.M.P.Q., de Lima, A. G. B. & da Silva, M. V. (2012), Numerical Analysis of Heat and Mass Transfer in Porous Media, Springer-Verlag Berlin Heidelberg. e-ISBN 978-3-642-30532-0.
10. Ferreira, J. A., Barbeiro, S., Pena, G., & Wheeler, M. F. (Eds.) (2012), Modelling and simulation in fluid dynamics in porous media (Vol. 28). Springer Science & Business Media.
11. Haitjema, H. M. (1995), Analytical Element Modeling of Groundwater, ACADEMIC PRESS, INC. ISBN 0-12-316550-4
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14. Ingham, D. B., & Pop, I. (Eds.) (2005), Transport phenomena in porous media III (Vol. 3). Elsevier. e-ISBN 9783642253331.
15. Miguel, M.A. and James, L. N. (1982), Seepage & Groundwater, Developments in Water Science Vol. 13 ISBN 0-444-41975-6.
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17. Sahimi, M.(2011), Flow and Transport in Porous Media and Fractured Rock: From Classical Methods to Modern Approaches (2nd Edition), Wiley-VCH Verlag GmbH & Co. KGaA.). e-ISBN 9783527636693.
18. Sato, K. and Iwasa, Y. (2000), Groundwater Hydraulics, Springer Japan. e-ISBN 978-4-431-53959-9.
19. Schotting, R. J., Van Duijn, H. C., & Verruijt, A. (Eds.) (2006), Soil mechanics and transport in porous media: selected works of G. de Josselin de Jong. Dordrecht: Springer Netherlands. e-ISBN 978-1-4020-3629-3.
20. Strack, O. D. (2017), Analytical groundwater mechanics. Cambridge University Press. ISBN 978-110-714-883-3
21. Tang, Y., Zhou, J., Yang, P., Yan, J., & Zhou, N. (2017). Groundwater engineering. Springer Singapore. e-ISBN 978-981-10-0669-2.
22. Verruijt, A. (1982), Theory of groundwater flow. Macmillan International Higher Education. ISBN 978-0-333-32959-7.

Related academic journals:

1. Environmental Fluid Mechanics
2. Journal of Hydrology
3. Journal of Hydraulic Engineering