GHENT UNIVERSITY

Course Specifications

Valid as from the academic year 2022-2023

Groundwater Modelling (C002656)

Due to Covid 19, the education and evaluation methods may vary from the information displayed in the schedules and course details. Any changes will be communicated on Ufora.

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 150 h** **Contact hrs** 50.0 h

Course offerings and teaching methods in academic year 2022-2023

A (semester 1)	English	Gent	online lecture	0.0 h
			lecture	20.0 h
			seminar: practical PC room classes	5.0 h
			project	25.0 h
B (semester 1)	English	Gent	online lecture	0.0 h
			lecture	20.0 h
			project	22.5 h
			seminar: practical PC room classes	5.0 h

Lecturers in academic year 2022-2023

Hermans, Thomas	WE13	lecturer-in-charge

Offered in the following programmes in 2022-2023	**crdts**	**offering**
Master of Science in Teaching in Science and Technology (main subject Geology)	6	A
Master of Science in Sustainable Land Management (main subject Land and Groundwater Management)	5	B
Master of Science in Geology	6	A
Master of Science in Geology	6	A
Exchange programme in Geology (master's level)	6	A

Teaching languages

English

Keywords

Conceptual model, groundwater flow, solute transport, heat transport, deterministic and stochastic inverse modelling, sensitivity analysis, numerical methods

Position of the course

In this course, the students will use their basic knowledge of hydrogeology to solve groundwater flow and transport equations using numerical models. In many conditions, due to the complexity of the subsurface and specific considerations, numerical models are the only way to assess groundwater flow and solute transport. We will illustrate groundwater flow modelling for the study of regional and local groundwater flow problems in the context of water supply, interaction between groundwater and surface water or dewatering operations. We will also tackle solute and heat transport, coupled with density-dependent groundwater flow for the study of salt water intrusion, ecohydrology, the sanitation of groundwater pollution or geothermal systems. For a good understanding of the methods, an introduction to numerical

methods (finite-difference and finite-element), inverse modelling and sensitivity analysis will be given.

Contents

1. Overview of the concepts of hydrogeology
2. General Introduction - Conceptual model
3. Saturated groundwater flow modelling
- Equations to solve
- Principle of the finite difference method
- Solving the steady-state equation through finite differences
- Solving the transient equation through finite differences
- Examples of the finite difference method
- Principle of the finite element method
- Solving the steady-state equation through finite elements
- Examples of the finite element method

4. Sensitivity analysis and Inverse modelling
- Introduction
- Objective function
- Manual calibration
- Sensitivity analysis
- Automatic calibration/Inversion
- Stochastic inversion

5. Solute transport modelling
- Reminders of solute transport : processes
- Solute transport equations
- Boundary conditions
- Solving solute transport equations
- Analogy for heat transport
- Examples

6. Unsaturated Flow and transport
- Definitions
- Hydrostatic in the unsaturated zone
- Unsaturated hydraulic conductivity
- Groundwater flow in the unsaturated zone
- Solute transport in the unsaturated zone

7. Density dependent flow
- Hydrostatic equations
- Saltwater intrusion
- Coupling flow and transport equation

Initial competences

A good knowledge of hydrogeological concepts is necessary. This course builds on certain learning outcomes of the course Hydrogeology.
A basic knowledge of mathematical concepts is necessary (derivates, integrals, differential equations). This course builds on certain learning outcomes of the course Mathematics I, II and III and Programming.

Final competences

1 Discuss the components of the conceptual model depending on the objective of the study and available data.
2 Distinguish the different numerical methods to solve flow and transport equations and identify their advantages/drawbacks.
3 Draw up and elaborate a numerical model of groundwater flow and if necessary an additional solute transport model.
4 Develop a methodological approach to calibrate/invert the model.
5 Critically assess the model output regarding hydrogeological processes and conditions.
6 Write a report about the model with the input data, the results and interpretations.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, project, seminar: practical PC room classes, online lecture

Extra information on the teaching methods

The theory is given through classical lessons with the integration of several examples and seminars from professionals.
The practical works are organised around a project where the students have to solve a specific problem related to groundwater flow and transport. They have to build their own model using the code MODFLOW, calibrate it against available data and use the model to achieve their specific objectives.

Learning materials and price

Slides of the theoretical lessons (Ufora)
Lebbe, L, 2004, Notes 'Groundwatermodelling'
Estimated cost: 5€

References

Bear J. & Cheng A.H.D., 2010, Modeling Groundwater Flow and Contaminant Transport, Springer, 834p.
Hill M.C. & Tiedeman C.R., 2007, Effective Groundwater Model Calibration: With Analysis of Data, Sensitivities, Predictions, and Uncertainty, Wiley, 480p.

Course content-related study coaching

Possibility to raise questions during the courses and the sessions dedicated to the project
Treatment of problems during the courses and the practical exercises
Step-by-step description of the use of the software (MODFLOW) used in the practicals and the project

Evaluation methods

end-of-term evaluation and continuous assessment

Examination methods in case of periodic evaluation during the first examination period

Written examination with open questions, oral examination

Examination methods in case of periodic evaluation during the second examination period

Written examination with open questions, oral examination

Examination methods in case of permanent evaluation

Assignment

Possibilities of retake in case of permanent evaluation

examination during the second examination period is possible

Extra information on the examination methods

The practical project is subject to a report on which is based the permanent evaluation. The project is discussed orally at the exam. There is a second examination chance for the permanent evaluation (a new report must be submitted).
The written examination is based on a scientific paper where a groundwater model is discussed.

Calculation of the examination mark

Periodic evaluation, written exam (50%) + periodic evaluation, oral exam (25%) and permanent evaluation, report (25%)