Department of Civil- and Environmental Engineering

Hochschule Bochum
TECHNIK WIRTSCHAFT GESUNDHEIT

MODULE BOOK

MASTER PROGRAMME GEOTHERMAL ENERGY SYSTEMS

(Examination Regulations 2025)

Winter Term 2026/27

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Introduction

1 Curriculum

The study plan listed here serves as a guideline for students and is not legally binding. In any case, the examination regulations of the degree programme and the study plan attached thereto are decisive.

All modules are graded and must be passed with at least a “sufficient” grade. The contribution of a module’s grade to the overall grade is determined by the regulations of the examination regulations of the degree programme.

1. Study Year

Compulsory Modules of the 1. Study Year

Compulsory Modules	Summer semester CP	Winter semester CP
Mathematik A – Höhere Analysis und Differentialgleichungen [1]	5	
Mathematik B – Statistik und Datenanalyse [1]		5
Mathematics C – Advanced Calculus and Differential Equations [1]	5	
Together	10	5

[1] One of the modules "'Mathematik A"', "'Mathematik B"', or "'Mathematics C"' must be taken as compulsory module, with only the module "'Mathematics C"' being offered in English. Another module out of the three can be taken as an elective complementary module, but the combination of "'Mathematik A"' and "'Mathematics C"' is not permitted.

Elective Compulsory Modules of the 1. Study Year

Elective Compulsory Modules	Summer semester CP	Winter semester CP
Process Simulation	5	
Groundwater Hydraulics	5	
Drilling Engineering	5	
Large Scale Thermal Energy Storage Systems		5
Geothermal Heat and Power Plants	5	
Geothermal Geology and Exploration		5
Hydro- and Geochemistry		5
Computational Wave Propagation	5	
Reservoir-Engineering		5
Rock Physics	5	
Applied Geophysics		5
Energy and Environmental Policy		5
Together	30	30

Complementary compulsory elective modules of the 1. Study Year

Elective Compulsory Modules	Summer semester CP	Winter semester CP
Interdisciplinary Energy Project 1	5	5
Interdisciplinary Energy Project 2	5	5
Engineering Studies 1	5	5
Engineering Studies 2	5	5
Engineering Measurement Technology		5
Key Competences [1]	5	5
Numerical Methods for Partial Differential Equations		5
Together	25	35

[1] The module "'Key Competences"' can be taken either in the summer semester or in the winter semester. With the exception of English language courses, students are free to choose one of the elective courses on key competencies offered by the BO Academy.

3. Semester

Compulsory Modules of the 3. Semester

Compulsory Module	Summer semester CP	Winter semester CP
Master Thesis and Colloquium	30	30
Together	30	30

CP - Credit points according to the European system for the transfer and accumulation of study achievements (ECTS credit points)

2 Competencies

The Master's programme in Renewable Energy Systems trains advanced analytical and methodological competencies. At the same time, the knowledge, skills, and competencies acquired in the first degree are deepened and expanded. Through the expansion of knowledge, graduates are enabled to identify specific aspects of common problems and solve them within a scientific framework. Additionally, they can develop solutions for problems that occur less frequently in practice but require a scientifically sound approach.

Graduates deepen their knowledge in such a way that they can reconsider topics from the Bachelor's curriculum using more sophisticated scientific methods. This leads to new solution approaches that surpass standard solutions in terms of accuracy and reliability or address areas not covered by standard methods.

This page summarizes the intended learning outcomes of the Master's programme in Renewable Energy Systems. The contributions of individual modules to these learning objectives can be found in the respective goal-module matrices of the study phases and study profiles on the following pages.

- **Knowing Technical Fundamentals.** Graduates know and understand advanced subject-specific fundamentals of renewable energy systems in general and geothermal energy systems in particular. They have acquired specialized methodological knowledge and broadened methodological competencies.
- **Knowing Scientific Fundamentals.** Graduates have acquired advanced theoretical knowledge with a scientific foundation in mathematical and natural science areas.
- **Applying Technical Fundamentals.** Graduates have applied their advanced subject-specific fundamental knowledge to complex problems.
- **Identifying and Solving Tasks.** Graduates can identify, formulate, and solve complex problems in renewable energy systems in general and geothermal energy systems in particular, considering established scientific insights and methods.
- **Developing Methods.** Graduates are capable of developing new, sophisticated, and innovative methods for verification and forecasting.
- **Planning in Projects.** Graduates can independently create plans and concepts in the field of renewable energies, particularly in geothermal energy systems, and determine the requirements for overall management and leadership of complex processes.
- **Evaluating Projects.** Graduates can assess complex projects holistically and interdisciplinary, considering sustainability, environmental compatibility, ecological and economic aspects, and contributions from other disciplines. They are able to independently acquire the current scientific knowledge on a research question and evaluate its usefulness for description, analysis, and problem-solving.
- **Practice-Oriented Research.** Graduates have acquired the ability to conduct independent scientific work. They can participate in the practical, methodological, and theoretical development of the subject, critically analyze and evaluate their own and others' research findings or information, and communicate them both in writing and orally.
- **Organizing Project Planning.** Graduates have developed scientific, technical, and social competencies (such as abstraction ability, system-analytical thinking, teamwork and communication skills, international and intercultural experience) and are therefore particularly prepared for leadership responsibilities.
- **Working Interdisciplinarily in a Team.** Graduates are able to work both independently and as members of international and mixed-gender teams, taking on particularly demanding tasks.
- **Communicating Content.** Graduates are capable of communicating controversially discussed topics and problems in renewable energy systems in general and geothermal energy systems in particular with both professional colleagues and a broader audience, including in foreign languages and intercultural contexts.
- **Organizing Projects.** Graduates are able to effectively organize and manage complex projects while growing into corresponding leadership responsibilities.

Studies

	Professional Competencies							Technical Competencies				
	Knowing Technical Fundamentals	Knowing Scientific Fundamentals	Applying Technical Fundamentals	Identifying Tasks and Developing Solutions	Developing Methods	Planning in Projects	Evaluating Projects	Applied Research	Organizing Project Planning	Working in Interdisciplinary Teams	Communicating Content	Organizing Projects
Summer semester												
Mathematik A		●●●	●●	●●●	●			●●			●	
Mathematics C		●●●	●●	●●●	●			●●			●	
Process Simulation	●●●	●●	●●	●●●	●			●●				
Groundwater Hydraulics	●●●	●	●●●	●●		●●						
Drilling Engineering	●●●	●●	●●●	●●		●		●			●	●
Geothermal Heat and Power Plants	●●●	●●	●●	●●●	●	●	●●●	●●			●	●●
Computational Wave Propagation	●●●	●●●	●●●	●●●	●			●●●		●	●	
Rock Physics	●●●	●●●	●●●	●●●	●			●●●			●	
Winter semester												
Mathematik B		●●●	●●	●●●	●		●	●●			●	
Large Scale Thermal Energy Storage Systems	●●●	●●	●●●	●●	●	●		●●		●●	●●	
Geothermal Geology and Exploration	●●●	●●	●●	●●	●	●		●●		●●	●	
Hydro- and Geochemistry	●●●	●●	●●	●●	●	●		●●		●●	●●●	
Reservoir-Engineering	●●●	●●●	●●●	●●	●●			●●●		●	●	
Applied Geophysics	●●●	●●●	●●●	●●●	●●●			●●●		●	●	
Energy and Environmental Policy	●●	●●●	●●			●		●●	●●	●	●●●	
Engineering Measurement Technology	●●●	●●	●●●	●●			●	●●		●	●●	●●
Numerical Methods for Partial Differential Equations	●	●●●	●●	●●	●●●	●		●●●			●●	
Each semester												
Interdisciplinary Energy Project 1	●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Interdisciplinary Energy Project 2	●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Engineering Studies 1	●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Engineering Studies 2	●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●
Key Competences				●●●	●●●	●●●			●●●	●●●	●●●	●●●
Master Thesis and Colloquium	●	●●●	●●●	●●●	●●●	●●●	●●●	●●●	●●●		●●●	

1 Modules in First Study Year

Compulsory Modules

1.1 Mathematik A – Höhere Analysis und Differentialgleichungen . . . 2
1.2 Mathematik B – Statistik und Datenanalyse . . . 3
1.3 Mathematics C – Advanced Calculus and Differential Equations . . . 4

Elective Compulsory Modules

1.4 Process Simulation . . . 5
1.6 Energy and Environmental Policy . . . 7
1.7 Groundwater Hydraulics . . . 8
1.8 Drilling Engineering . . . 9
1.9 Large Scale Thermal Energy Storage Systems . . . 10
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1.13 Computational Wave Propagation . . . 14
1.14 Reservoir-Engineering . . . 15
1.15 Rock Physics . . . 16
1.16 Applied Geophysics . . . 17

Complementary compulsory elective modules

1.5 Numerical Methods for Partial Differential Equations . . . 6
1.17 Interdisciplinary Energy Project 1 . . . 18
1.18 Interdisciplinary Energy Project 2 . . . 19
1.19 Engineering Studies 1 . . . 20
1.20 Engineering Studies 2 . . . 21
1.21 Engineering Measurement Technology . . . 22
1.22 Key Competences . . . 23

1.1 Module Mathematik A – Höhere Analysis und Differentialgleichungen

Module title Note Code	**Mathematik A – Höhere Analysis und Differentialgleichungen** ***Teaching language is German*** M1-MatheA
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr.-Ing. Matthias Baitsch
Lecturers	– Prof. Dr.-Ing. Matthias Baitsch – Dr.-Ing. Denis Busch
Language	Deutsch
Workload	150 hours (30h Lecture, 30h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Civil Engineering – Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	Die Studierenden beherrschen die wichtigsten mathematischen Grundlagen zur Beschreibung physikalischer Phänomene durch Differentialgleichungen. Sie können ausgewählte gewöhnliche Differentialgleichungen zweiter Ordnung aufstellen, lösen und die Eigenschaften der Lösung beurteilen. Die Studierenden sind in der Lage, grundlegende Verfahren zur Herleitung partieller Differentialgleichungen aus physikalischen Gesetzen anzuwenden und kennen die dabei auftretenden Differentialoperatoren. Systeme mit einer harmonischen Anregung können sie mithilfe der komplexen Exponentialfunktion untersuchen. Sie kennen wichtige Reihenentwicklungen von Funktionen und deren Anwendungen.
Knowledge	– Komplexe Zahlen und komplexe Exponentialfunktion – Differentialgleichung des Einmassenschwingers – Grenzwerte, Stetigkeit und partielle Ableitungen von Funktionen im R^n – Gradient, Hesse-Matrix, Jacobi-Matrix – Differentialoperatoren und ausgewählte partielle Differentialgleichungen – Entwicklung von Funktionen in Taylor- und Fourierreihen
Skills	– Systeme mit dynamischer Anregung analysieren – Eigenschaften von Abbildungen $R^n \rightarrow R^m$ untersuchen – Gewöhnliche und partielle Differentialgleichungen aufstellen – Nichtlineare Gleichungssysteme mit dem Newton-Verfahren lösen – Das Frequenzspektrum diskreter Signale untersuchen
Competencies	– Komplexe physikalische Vorgänge mathematisch modellieren – Mathematisch ausgerichtete Literatur für die eigene Arbeit nutzen
Content	– Rechenregeln für komplexe Zahlen – Gewöhnliche DGL zweiter Ordnung mit konstanten Koeffizienten – Punktfolgen und Grenzwerte von Funktionen mehrerer Variablen – Partielle Ableitungen, Richtungsableitung und totale Differenzierbarkeit – Nabla-Operator, Divergenz, Rotation und Laplace-Operator – Fourierreihen und diskrete Fouriertransformation – Ausgewählte partielle Differentialgleichungen (Wärmeleitungsgleichung etc.)
Teaching format	Studierende erarbeiten sich Lehrinhalte mithilfe von Erklärvideos und schriftlichen Unterlagen selbständig, an der Hochschule werden in kleinen Gruppen Übungsaufgaben gelöst und Fragen diskutiert (Flipped-Classroom).
Examination with elements	– Portfolioprüfung mit den Elementen: Lösen von Aufgaben (20%), Schriftlicher Test (40%), Fachgespräch (40%) und Lernprozess-Reflektion/Resümee (unbewertet) – Im Wintersemester: Klausur (120 Minuten)
Media	– Skript Mathematik A – Erklärvideos auf Youtube
Literature	– Grieser, D.: Analysis 1, Eine Einführung in die Mathematik des Kontinuums – Forster, O.: Analysis 2 (Differentialrechnung im R^n, gewöhnliche DGLn)

1.2 Module Mathematik B – Statistik und Datenanalyse

Module title	**Mathematik B – Statistik und Datenanalyse**
Note	***Teaching language is German***
Code	M1-MatheB
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr.-Ing. Matthias Baitsch
Lecturers	Prof. Dr.-Ing. Matthias Baitsch
Language	Deutsch
Workload	150 hours (30h Lecture, 30h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Civil Engineering – Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	Die Veranstaltung befähigt dazu, komplexe statistische Daten (z.B. aus Berechnungen, Erhebungen oder Messungen) nutzen, analysieren, interpretieren und kommunizieren zu können. Hierfür erlernen die Studierenden statistische Grundbegriffe und Methoden sowie moderne Werkzeuge der computergestützten Datenanalyse.
Knowledge	– Zentrale Aufgaben und Anwendungsfelder der Statistik – Grundbegriffe der Statistik (Grundgesamtheit, Stichprobe, Arten von Merkmalen) – Kenngrößen von Verteilungen (Lagemaße, Streuungsmaße, Konzentrationsmaße) – Methoden zur Untersuchung von zwei Merkmalen (Korrelation, Regression) – Elemente der Programmiersprache R – Pakete aus dem tidyverse
Skills	– Empirische Lage- und Streuungsparameter berechnen – Zusammenhänge zwischen Merkmalen darstellen und quantifizieren – Datensätze mit geeigneten Graphiken visualisieren – Regressionsgerade bestimmen und Anpassungsgüte quantifizieren – Daten aus verschiedenen Quellen zu importieren, bereinigen und zu transformieren – Datenanalysen und Visualisierungen mit ggplot2 durchzuführen – Reproduzierbare Analysen mit Quarto erstellen
Competencies	– Informationen aus Datensätzen gewinnen und interpretieren – Statistische Methoden kritisch zu hinterfragen und angemessen auszuwählen – Ergebnisse verständlich zu kommunizieren und visualisieren
Content	– Mathematische Methoden der Statistik – Einführung in R und das Tidyverse – Aufbereitung von Daten – Explorative Datenanalyse – Räumliche Daten
Teaching format	Studierende erarbeiten sich Lehrinhalte mithilfe von Erklärvideos und schriftlichen Unterlagen selbständig, an der Hochschule werden in kleinen Gruppen Übungsaufgaben gelöst und Fragen diskutiert (Flipped-Classroom).
Examination	Hausarbeit mit mündlicher Prüfung
Media	– Skript Mathematik B – Erklärvideos auf Youtube
Literature	– Fahrmeir, L., Künstler, R., Pigeot, I., Tutz, G.: Statistik, Wege zur Datenanalyse, Springer – Mittag, H.J.: Statistik, Eine Einführung mit interaktiven Elementen, Springer – Wickham, H., & Grolemund, G.: R for Data Science. O'Reilly

1.3 Module Mathematics C – Advanced Calculus and Differential Equations

Module title	**Mathematics C – Advanced Calculus and Differential Equations**
Code	M1-MatheC
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr. E. H. Saenger
Lecturers	N. N.
Language	English
Workload	150 hours (45h Lecture, 30h Exercise, 75h Self driven work)
Credit points / Contact time	5 Credit points / 5 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Civil Engineering – Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	Students learn the most important mathematical foundations for the description of physical phenomena by differential equations. They can set up selected ordinary differential equations of second order and can evaluate the properties of the solution. The students are able to apply basic methods for the derivation of partial differential equations from physical laws and know the occurring differential operators. Systems with harmonic excitation can be investigated them by the complex exponential function. They know important series expansions of functions and their applications.
Knowledge	– Complex numbers and complex exponential function – Differential equation of the single-mass oscillator – Limits, continuity and partial derivatives of functions within Rn – Gradient, Hesse-Matrix, Jacobi-Matrix – Differential operators and selected partial differential equations – Development of functions in Taylor and Fourier series
Skills	– Analyze systems with dynamic excitation – Study the properties of transformations Rn to Rm – Set up ordinary and partial differential equations – Solve nonlinear equation systems using the Newton method – Explore the frequency spectrum of discrete signals
Competencies	– Mathematically modeling of complex physical processes – Mathematisch ausgerichtete Literatur für die eigene Arbeit nutzen – Use mathematically oriented literature for one's own work
Content	– Calculation rules for complex numbers – Ordinary second order differential equations with constant coefficients – Point sequences and limits of functions of several variables – Partial derivatives, directional derivation and total differentiability – Nabla operator, divergence, rotation and Laplace operator – Selected partial differential equations (Laplace, Poisson, heat equation, etc.) – Taylor series – Fourier series and discrete Fourier transform – Newton's method for systems of nonlinear equations
Teaching format	Lecture with change between lecture (blackboard and beamer) and activating Elements (discussion, tasks, etc.). Exercise with pre-calculation and independent work. Independent work with task sheets and comprehensive e-learning offer.
Examination	Written exam (120 minutes, in presence at the university or online)
Media	– Blackboard – Digital projector
Literature	– Shima and Nakayama: Higher Mathematics for Physics and Engineering (Springer) – Tenebaum and Pollard: Ordinary Differential Equations (Dover books)

1.4 Module Process Simulation

Module title Code	**Process Simulation** M1-ProSim
Duration / Frequency	One semester / Each year in summer term
Responsible	Professur Energieverfahrenstechnik
Lecturers	N.N.
Language	English
Workload	150 hours (30h Lecture, 15h Exercise, 15h Practica, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	Bachelor's Module Power-to-X
Study programmes	– Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	Students are familiar with the methods of process simulation and are able to model processes in the area of energy related process engineering with the help of software solutions such as Aspen Plus. They can assess the quality of the software solutions and are able to develop strategies to improve the simulation results.
Knowledge	– Modelling of process systems – Phase Equilibria – Reaction Engineering – Models in Aspen Plus
Skills	– Selection of appropriate model blocks – Creating a flowchart simulation
Competencies	– Evaluate the quality of simulation results – Developing strategies to improve simulation results
Content	– Introduction to process simulation and numerical methods – Modelling of transport processes and reactions – Applications in various branches of industry – Validation and verification of simulation models – Optimisation of processes with simulation techniques
Teaching format	Seminar-based lecture, computer-aided exercises, working on your own problem in a practical course
Examination with elements	– Mündliche Prüfung (Oral exam) – Prüfung nur im Sommersemester (Exam only in the summer semester)
Media	– Lecture notes – Digital projector – Digital media (e.g. moodle, H5P, kahoot) – Lecture experiments – Excercises
Literature	Hangos, Cameron (2001): Process Modelling and Model Analysis

1.5 Module Numerical Methods for Partial Differential Equations

Module title	**Numerical Methods for Partial Differential Equations**
Code	M1-NumPDE
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr.-Ing. Matthias Baitsch
Lecturers	Prof. Dr.-Ing. Matthias Baitsch
Language	Deutsch / Englisch
Workload	150 hours (45h Lecture, 15h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	Knowledge of multidimensional calculus
Study programmes	Master Geothermal Energy Systems
Learning goals	Students understand the mathematical foundations of the finite element method (FEM) for the approximate solution of partial differential equations. They can implement the method in a programming environment for various problem scenarios and perform calculations using a self-developed program. They are familiar with the capabilities and limitations of FEM-based simulations and can competently apply existing programs in practice.
Knowledge	– Strong and weak formulation of boundary value problems – Approximation of functions using suitable basis functions – Properties and convergence of the approximate solution – Sources of errors in FEM calculations
Skills	– Performing calculations with FEM programs – Deriving and implementing element formulations
Competencies	– Creating suitable numerical models for engineering applications – Critically analyzing calculation results and identifying potential error sources – Contributing to the development of FEM programs
Content	– Partial differential equations and boundary value problems – Weak formulation of boundary value problems: test functions, linear and bilinear forms – Approximation of functions using suitable basis functions – Conversion of problems into a linear system of equations – Properties of the system matrix – Element-wise integration – Heat conduction – Acoustic wave propagation – Elasticity problems
Teaching format	Students independently acquire course content using explanatory videos and written materials. At the university, exercises and programming tasks are solved in small groups, and questions are discussed (Flipped Classroom).
Examination	Homework with presentation
Media	– Instructional videos – Blackboard – Extensive exercises
Literature	– Johnson, C.: Numerical Solutions of Partial Differential Equations by the Finite Element Method, Dover – Fish, J. and Belytschko, T.: A First Course in Finite Elements, Wiley

1.6 Module Energy and Environmental Policy

Module title	**Energy and Environmental Policy**
Code	M1-EEPol
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr. Stephan Sommer
Lecturers	Prof. Dr. Stephan Sommer
Language	English
Workload	150 hours (60h Seminar, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	Students acquire the skills to scientifically analyse energy and environmental economic issues. They learn the basic principles of German, European and international energy and environmental policy.
Knowledge	– Fundamentals of economic theory in energy and environmental economics – Current problems of (inter)national energy and environmental policy – (Efficient) instruments for the transformation to a decarbonised economy – Fundamentals of empirical research (definition, methods, areas of application) – Research sources for specialist literature on energy and environmental economics topics
Skills	– Knowing the influences of energy and environmental policy on the energy markets – Identifying and assessing the external effects of energy supply – Analysing empirical studies for their methods and describing their contents – Researching literature for a given specialist topic – Quoting content from this specialist literature correctly and presenting it in a way that others can understand
Competencies	– Being able to exchange views on energy and environmental policy problems in the transformation of the energy system – Assessing the influence and suitability of energy and environmental policy instruments for solving problems in the transformation of the energy system – Evaluating new energy technologies under sustainability perspective
Content	– Resource economics and energy economics – Fundamentals of environmental policy – Current political and economic problems in the field of environmental and climate economics – Internalisation of external effects – Merit order effect – International environmental policy – New technologies and sustainability
Teaching format	Seminar-based teaching
Examination with elements	– Hausarbeit mit Präsentation (Term paper with presentation) – Prüfung nur im Wintersemester (Exam only in the winter term)
Media	– Lecture notes – Digital projector
Literature	– Zweifel P., A. Praktiknjo, G. Erdmann; Energy Economics: Theory and Applications, Springer – Endres, A., V. Radke; Economics for Environmental Studies, Springer – Phaneuf, D., T. Requate; A Course in Environmental Economics, Cambridge University Press – Additional literature is provided in the form of referenced journal articles

1.7 Module Groundwater Hydraulics

Module title	**Groundwater Hydraulics**
Code	M1-GrwHyd
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr.-Ing. Bastian Welsch
Lecturers	Prof. Dr.-Ing. Bastian Welsch
Language	English
Workload	150 hours (30h Lecture, 30h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Civil Engineering – Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The course deals with the basic physical phenomena of groundwater flow, and groundwater flow related mass and heat transport processes in the subsurface. Moreover, it gives an introduction to practice related numerical simulation of these processes. Upon successful completion of the module, students will be able to …
Knowledge	– Decribe the fundamentals of hydrogeology. – Explain groundwater flow and the related mass and heat transfer processes in the subsurface.
Skills	– Plan and design water wells / plan, perform and evaluate well pumping tests. – Perform numerical groundwater flow and transport simulations in a state-of-the-art simulation environment.
Competencies	– Capture and assess the hydrogeological situation at a site and to transfer this into a numerical model concept. – Evaluate and critically question the results of a numerical groundwater flow and transport simulation.
Content	– Introduction to Hydrogeology – Darcy Flow in Confined and Unconfined Aquifers – Variable Saturated Media – Material Transport in Groundwater – Heat Transport in Groundwater – Density Dependent Flow – Well Hydraulics and Pumping Tests – Groundwater flow-, heat and mass transport- simulation
Teaching format	Lecture, practice-oriented exercises, software training
Examination with elements	– Portfolioprüfung (Elemente: zwei schriftliche Tests [je 25 %], Lösen einer Modellierungsaufgabe [50%], + Reflexion des Lernprozesses [unbewertet]/Resümee). / Portfolio examination (elements: two written tests [25% each], solving a modeling problem [50%], + learning process reflection [unassessed]/resume). – Prüfung nur im Sommersemester / Exam only in the summer semester
Media	– Visualizer, blackboard, beamer – E-learning platform Moodle – Slide script – Software FEFLOW
Literature	– Manual of Software FEFLOW – Further literature recommendation will be given in the lectures

1.8 Module Drilling Engineering

Module title Code	**Drilling Engineering** M1-Drill
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr. Bastian Welsch
Lecturers	Dipl.-Ing. Volker Wittig, M.Sc.
Language	English
Workload	150 hours (45h Lecture, 15h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The course presents an introduction to drilling technologies relevant for shallow and deep geothermal energy, focussing mainly on conventional mud drilling techniques as well as to some extent on advanced deep drilling technologies. Students learn how to plan a drilling project including wellbore planning and selection of toolings and devices. Upon successful completion of the module, students will be able to …
Knowledge	– Describe the assembly of a drilling rig and the drill string, as well as the tasks of the individual components – Describe the operation, advantages and disadvantages of mud drilling – Explain the mud circulation system and describe the application areas of the various mud additives – Explain different LWD / MWD techniques
Skills	– Calculate casing designs – Define the composition of the cost structure of a drilling project
Competencies	– Develop drilling concepts adapted to the geological conditions and the project purposes – Recognise potential drilling problems and work out solutions to avoid or overcome these problems – Identify drilling risks and initiate appropriate countermeasures
Content	– Deep drilling basics; mechanical rock destruction process – Drilling techniques and process – Rotary drilling – Percussion drilling – Directional drilling – Innovative and unconventional drilling techniques (thermal, hydraulic, coiled tubing) – Drilling specific laboratory analysis – Mud logging – Health, safety issues and environmental impacts of drilling projects
Teaching format	Classroom and hands on lectures, field work on the rig and its auxiliary equipment, laboratory experiments, practical case studies.
Examination with elements	– Referat / Presentation – Prüfung nur im Sommersemester / Exam only in the summer semester
Media	– Projector – Blackboard – Script – Drilling Rig and Tooling
Literature	

1.9 Module Large Scale Thermal Energy Storage Systems

Module title	**Large Scale Thermal Energy Storage Systems**
Code	M1-GeoTES
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr.-Ing. Bastian Welsch
Lecturers	Prof. Dr.-Ing. Bastian Welsch
Language	English
Workload	150 hours (15h Lecture, 15h Exercise, 15h Seminar, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The course provides a sound understanding of the concepts, technologies and applications of thermal energy storage systems. Students learn to analyse relevant thermodynamic processes, consider design and operational aspects and develop application-related solutions to problems. The aim is to enable students to develop and implement efficient and sustainable solutions in the field of thermal energy storage. Upon successful completion of the module, students will be able to …
Knowledge	– Understand the basics of thermal energy storage – Recall the working principles of different storage technologies – Explain the thermodynamic and kinetic processes involved in energy storage
Skills	– Apply analysis techniques to evaluate storage technologies and systems – Analyse and integrate energy storage systems into existing energy systems – Apply problem-solving strategies in the context of storage requirements and optimisation
Competencies	– Assess design and operational aspects of thermal energy storage systems – Develop efficient and sustainable solutions for storage challenges – Assess the economics, reliability and environmental impact of storage systems
Content	– Energy Storage Systems and TES – Power-to-Heat and Heat Pumps – Chemical amd Latent Heat Storage – Sensible Heat Strorge – Geothermal and Solar District Heating – Seasonal Heat Storage Systems – Tanks and Ice-Storage – M-TES – Borehole Thermal Energy Storage – Aquifer Thermal Energy Storage – Assessment of Seasonal TES Systems – Introduction to Simulation with Modelica
Teaching format	Lectures alternate with exercises in which students learn and use Modelica-based software to simulate and optimise a thermal storage system in its entirety.
Examination with elements	– Hausarbeit mit Präsentation / Term paper with presentation – Prüfung nur im Wintersemester / Exam only in the winter semester
Media	– Visualizer, blackboard, beamer – E-learning platform Moodle – Slide script – Software tutorial
Literature	– Steinmann (2022): Thermal Energy Storage for Medium and High Temperatures – Dincer and Rosen (2021): Thermal Energy Storage: Systems and Applications

1.10 Module Geothermal Heat and Power Plants

Module title	**Geothermal Heat and Power Plants**
Code	M1-GeoCHP
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr.-Ing. Bastian Welsch
Lecturers	Prof. Dr.-Ing. Bastian Welsch
Language	English
Workload	150 hours (30h Lecture, 15h Exercise, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	Parallel attendance of the course Groundwater Hydraulics
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The course focuses on deep geothermal systems. The students will learn the basic componets, thermodynamic principles and stages in the development of geothermal power plants. Upon successful completion of the module, students will be able to …
Knowledge	– Explain the components of deep geothermal systems and geothermal power plants. – Differentiate methods of enhancing geothermal reservoirs. – Distinguish between different types of power plants, explain their operating principle and illustrate it in the form of process diagrams.
Skills	– Understand the thermodynamic processes in a geothermal power plant and estimate the output of a power plant via simplified thermodynamic considerations. – Weigh the social and environmental implications associated with deep geothermal projects and know appropriate actions to counteract them.
Competencies	– Evaluate site-specific conditions and, based on this, develop the deep geothermal concept best suited for the site in question. – Explain the steps required for successful geothermal project development and adapt them to the particular constraints.
Content	– Deep Geothermal Systems and Global Ressources – Types of Geothermal Power Plants – Thermodynamics of Geothermal Power Plants – Heat Exchanger System / Submersible Pumps – Pumping the Reservoir – Corrosion and Scaling Processes – Enhancing Geothermal Systems – Geothermal District Heating – Social and Environmental Impacts – Development Stages of a Deep Geothermal Project – Economics, Finance, and Risk Analysis of a Geothermal Project – Co-production of Lithium
Teaching format	Lecture, practice-oriented exercises, group work, components of self-study
Examination	Klausur (90 Minuten) / Written exam (90 minutes)
Media	– Visualizer, blackboard, beamer – E-learning platform Moodle – Slide script
Literature	– DiPippo, R.: Geothermal Power Plants; DiPippo, R. (Edit.): Geothermal Power Generation. – Huenges, E.: Geothermal Energy Systems.

1.11 Module Geothermal Geology and Exploration

Module title	**Geothermal Geology and Exploration**
Code	M1-GeoExp
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr.-Ing. Bastian Welsch
Lecturers	Prof. Dr.-Ing. Bastian Welsch
Language	English
Workload	150 hours (30h Lecture, 15h Seminar, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	Students will learn the fundamentals of geothermal geology, the differentiation of different geothermal play types and the application of methods and concepts to estimate the geothermal potential of a certain region. Upon successful completion of the module, students will be able to …
Knowledge	– Distinguish different geothermal play types and sketch their typical structure, – Specify the thermal and hydraulic characteristics of different geothermal plays, – Specify ranges of thermo-physical and hydraulic reservoir properties of a reservoir for an efficient production, – Explain the procedure for outcrop analog studies,
Skills	– Identify suitable regions for geothermal power and heat generation from their geological setting, – Identify problematic geological formations for shallow geothermal systems, – Apply methods to estimate the geothermal potential of a certain location,
Competencies	– Transfer the geothermal play type concept to unexplored geothermal locations, – Develop adapted geochemical and geophysical exploration strategies, – Extract relevant information from geoscientific publications, to present them and to question and discuss the scientific positions.
Content	– Introduction into geothermal ressources assessment – Introduction into geological systems – Fundamentals of geothermal play type concepts – Different geothermal plays – Exploration strategies – Case studies – Damage cases in shallow geothermal geology
Teaching format	In the first part the basics will be taught as a lecture (with activating elements such as group work), in the further part students will independently delve into special topics and present them to the commiliotons in the form of presentations and discuss them in a seminar-like manner. Moreover, the students will get some exercises to solve.
Examination with elements	– Portfolioprüfung (Elemente: zwei schriftliche Tests [je 30%], Präsentation [40%], + Reflexion des Lernprozesses [unbewertet]/Resümee). / Portfolio examination (elements: two written tests [30% each], presentation [40%], + learning process reflection [unassessed]/resume). – Prüfung nur im Wintersemester / Exam only in the winter semester
Media	– Data projector – White Board or classic board – Moodle as e-learning plattform – Lecture slides
Literature	– Harvey, C, Rüter, H., Moeck, I., Beardsmore,G (2016): Best practice on geothermal exploration – Press, F.; Siever, R. (1995): Earth.- Spektrum Akad. Verlag, Heidelberg – Weber, J., Schulz, R. et al. (2016): Geothermal Energy, Leibniz Institute for Applied Geophysics

1.12 Module Hydro- and Geochemistry

Module title	**Hydro- and Geochemistry**
Code	M1-GeoChe
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr.-Ing. Bastian Welsch
Lecturers	Dr. Isabella Nardini
Language	English
Workload	150 hours (30h Lecture, 15h Exercise, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The students learn to interprete chemical processes and fluid-/rock-reactions at low to moderate pT-conditions in the upper geopsphere and in technical geothermal systems.
Knowledge	– General chemical composition of rocks – Fundamentals of water-rock interaction – Chemical composition of groundwater and its regional dependencies – Principles of single-phase and 2-phase flow – Thermodynamics of fluids in the geosphere – Fundamentals of corrosion and scaling processes in the geopsphere and related technical systems – Groundwater and minewater chemistry
Skills	– Groundwater and gas sampling – Chemical analysis of groundwater – Solving simple stoichiometric equations – Simulation of component transport in groundwater – Prediction of scaling and corrosion processes
Competencies	– Predict fluid-rock interactions at given pT-conditions – Simulation of mineral solubility – Estimation of simple geochemical reservoir characteristics – Development of geochemical sampling and monitoring concepts
Content	– Groundwater quality – Physical and chemical basics – Processes in fluid flow and 2-phase flow – Thermodynamic model for mineral solubility in aqueos fluids – Fluids at elevated pressure and temperature – Element transport – Geochemical systems of different rock types – The carbonate system – Microbiology of groundwater bodies – Corrosion and scaling processes – Regional geochemical studies and exploration strategies – Toxicology of ground water compounds – Introduction to numerical simulation (PhreeqC)
Teaching format	Lecture and practical computer exercises, project-based self-study, digital teaching format (100 %), synchronous with asynchronous elements.
Examination with elements	– Hausarbeit mit Präsentation / Term paper with presentation – Prüfung nur im Wintersemester / Exam only in the winter semester
Media	– Projector and whiteboard – Textbooks and script – Field sampling and laboratory analysis equipment – Computer-based simulation tools
Literature	– Script – Textbooks – Stanford / IGA scientific paper database

1.13 Module Computational Wave Propagation

Module title Code	**Computational Wave Propagation** M2-CompWP
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr. E. H. Saenger
Lecturers	Prof. Dr. E. H. Saenger
Language	English
Workload	150 hours (45h Lecture, 45h Exercise, 60h Self driven work)
Credit points / Contact time	5 Credit points / 6 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The students will learn the fundamentals of computational wave propagation. This broad range of knowledge will be teached with a special emphasis to geothermal and hydrocarbon exploration.
Knowledge	– To know the fundamentals of computational wave propagation – E.g. to know how to use high-performance computer systems – E.g. to understand the application of computational wave propagation to digital rock physics
Skills	– To apply the fundamentals of computational wave propagation – E.g. to predict effective material properties – E.g. to model wave propagation in complex systems like geothermal reservoirs or concrete
Competencies	– To apply the fundamentals of computational wave propagation to scientific projects – E.g. to upscale elastic properties to understand field scale observations – E.g. to interpret uncertainties in the computational wave propagation workflow
Content	– The basics of the computational wave propagation will be introduced: generation of a digital elastic model, preparation of all input files to start a simulation, visualization and processing of all output files, calculation of physical properties – The basics of parallel computing on on high-performace computer systems will be introduced. – The basics of finite-different-schemes to solve the elastodynamic wave equation will be introduced. – The parallel computer program 'Heidimod' to model elastic waves in highly heterogeneous and anisotropic media will be introduced in detail and will be applied to problems in the field of computational wave propagation
Teaching format	Lecture and computer exercises to be solved
Examination with elements	– Lab report (Homework) – Exam only in the summer term
Media	– Digital projector – Blackboard – Laptop
Literature	Skript

1.14 Module Reservoir-Engineering

Module title Code	**Reservoir-Engineering** M1-ResEng
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr. E. H. Saenger
Lecturers	Prof. Dr. E. H. Saenger
Language	English
Workload	150 hours (45h Lecture, 15h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The students will learn the fundamentals of reservoir engineering. This broad range of knowledge will be teached with a special emphasis to geothermal and hydrocarbon exploration.
Knowledge	– To know the fundamentals of reservoir engineering. – E.g. to understand microseismic monitoring – E.g. to understand geophysical data from boreholes
Skills	– To apply the fundamentals of reservoir engineering. – E.g. to estimate the risks of reservoir stimulations – E.g. to estimate reservoir permeability
Competencies	– To transfer the fundamentals of reservoir engineering to scientific projects – E.g. to transfer the knowledge of several case histories to new sites. – E.g. to plan a reservoir monitoring system
Content	– Fundamentals of reservoir engineering with the focus on geothermal applications – Interpretation of downhole measurements – Interpretation of spinner results – Measuring reservoir permeability – Conceptual models of geothermal fields – Reservoir modelling – Reservoir monitoring – Reservoir stimulation – Case Histories
Teaching format	Lecture with several interactions with the students
Examination with elements	– Oral exam (in presence at the university or online) – Exam only in the winter term
Media	– Digital projector – Black board
Literature	– Grant MA and Bixley PF, 2011; Geothermal Reservoir Engineering – Zoback MD, 2010; Reservoir Geomechanics

1.15 Module Rock Physics

Module title	**Rock Physics**
Code	M2-RocPhy
Duration / Frequency	One semester / Each year in summer term
Responsible	Prof. Dr. E. H. Saenger
Lecturers	Prof. Dr. E. H. Saenger
Language	English
Workload	150 hours (45h Lecture, 15h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The students will learn the fundamentals of rock physics. This broad range of knowledge will be teached with a special emphasis to geothermal and hydrocarbon exploration.
Knowledge	– To know the fundamentals of rock physics – E.g. to know the Gassmann and Biot theory – E.g. to know several theories to predict effective rock properties
Skills	– To apply the fundamentals of rock physics – E.g. to estimate porosities of reservoir rocks – E.g. to estimate the permeability of reservoir rocks
Competencies	– To transfer the fundamentals of rock physics to scientific projects – E.g. to interpret field data on the basis of rock physical relationships – E.g. to understand the uncertainties of laboratory investigations
Content	– Fundamentals of rock physics. – Introduction to physical properties of sedimentary rocks (e.g. porosity, electrical conductivity, fluid transport properties). – Theoretical and experimental estimations of those properties. – Rock physical relationships from a theoretical, experimental and numerical point of view. – Upscaling: Connections of rock physical relationships on multiple scales. – Laboratory experiments.
Teaching format	Lecture with several interactions with the students
Examination	Lab report (Homework)
Media	– Blackboard – Digital projector
Literature	– Mavko, G., Mukerji, T. & Dvorkin, J., 1998; The rock physics handbook: tools for seismic analysis in porous media. – Schön, J., 1997; Physical Properties of Rocks: Fundamentals and Principles of Petrophysics – Aki, K., P. Richards, 1980; Quantitative Seismology

1.16 Module Applied Geophysics

Module title	**Applied Geophysics**
Code	M1-APPGEO
Duration / Frequency	One semester / Each year in winter term
Responsible	Prof. Dr. E. H. Saenger
Lecturers	Prof. Dr. E. H. Saenger
Language	English
Workload	150 hours (45h Lecture, 15h Exercise, 90h Self driven work)
Credit points / Contact time	5 Credit points / 4 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	– Master of Environmental Engineering – Master Renewable Energy Systems – Master Geothermal Energy Systems
Learning goals	The students will learn the fundamentals of applied geophysics. This broad range of knowledge will be teached with a special emphasis to geothermal and hydrocarbon exploration.
Knowledge	– To know the fundamentals of applied geophysics – E.g. seimic wave propagation – E.g. gravitation
Skills	– To apply the fundamentals of applied geophysics – E.g. seismic imaging – E.g. interpretation of geophysical data
Competencies	– To transfer the fundamentals of applied geophysics to scientific projects – E.g. to apply elelctrical methods for leak tests of landfills – E.g. to evaluate reservoir properties from different geophysical techniques
Content	– Fundamentals of applied geophysics – (a) Seismic – Introduction to exploration seismics, wave propagation, fundamental rockphysics, refraction and reflection seismic data processing – (b) Potential methods – Rockphysics of potential methods, anomalies, measuring devices in gravimetry and magnetics, interpretation of gravimetric and magnetics data – (c) Geoelectric – Electric conductivity of rocks, geoelectric sounding and mapping, selfpotential method, induced polarization, VFL, VLF-R, magnetotellurics, geoelectric measuring devices
Teaching format	Lecture with several interactions with the students
Examination with elements	– Oral exam (in presence at the university or online) – Exam only in the winter term
Media	– Blackboard – Digital projector
Literature	– Telford, W.M., Geldart, L.P., Sheriff, R.E., 1990; Applied Geophysics – Keary, P. & Brooks, M, 1990; An Introduction to Geophysical Prospecting – Sheriff, R. & L. Gelart, 1995; Exploration Seismology

1.17 Module Interdisciplinary Energy Project 1

Module title	**Interdisciplinary Energy Project 1**
Code	M1-IEPen1
Duration / Frequency	One semester / Each semester
Responsible	All professors of the study programme
Lecturers	All professors of the study programme
Language	English
Workload	150 hours (45h Seminar, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	Master Geothermal Energy Systems
Learning goals	Students will have the ability to work independently and in teams on subject-specific problems according to scientific principles. They will have developed a basic understanding of the working methods, ways of thinking, methods, and cognitive possibilities of different energy technology disciplines, as well as project management in an interdisciplinary team. After successfully completing this module, students are able to …
Knowledge	– Reproduce the theoretical knowledge required to work on the project
Skills	– Apply basic project management methods – Organise and communicate in a team – Distribute subtasks fairly among the team members according to their individual competences – Recognise missing specialist knowledge and acquire it independently – Present project results in an adequate written and oral form in a collaborative manner – Evaluate energy projects with regard to their economic viability and compare different variants
Competencies	– Transfer the knowledge they have acquired during their studies to a more complex, interdisciplinary problem/project task in the field of renewable energy systems – Develop various solutions to the problem/project task in a team and evaluate the solutions developed using suitable methods – Identify a preferred option from the solutions developed and defend it in front of stakeholders
Content	– Depending on the task – Mandatory: Fundamentals of investment calculation (LCOE / LCOH, CAPEX, OPEX)
Teaching format	Student project teams work on excerpts from an interdisciplinary planning or research project with a practical and energy-related focus. Supervisors provide specialist knowledge and specific boundary conditions through seminar-style teaching, which is then further developed by the students themselves.
Examination	Term paper with presentation
Media	Depending on the supervisor
Literature	Depending on the task

1.18 Module Interdisciplinary Energy Project 2

Module title Code	**Interdisciplinary Energy Project 2** M1-IEPen2
Duration / Frequency	One semester / Each semester
Responsible	All professors of the study programme
Lecturers	All professors of the study programme
Language	English
Workload	150 hours (45h Seminar, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	Master Geothermal Energy Systems
Learning goals	Students will have the ability to work independently and in teams on subject-specific problems according to scientific principles. They will have developed a basic understanding of the working methods, ways of thinking, methods, and cognitive possibilities of different energy technology disciplines, as well as project management in an interdisciplinary team. After successfully completing this module, students are able to …
Knowledge	– Reproduce the theoretical knowledge required to work on the project
Skills	– Apply basic project management methods – Organise and communicate in a team – Distribute subtasks fairly among the team members according to their individual competences – Recognise missing specialist knowledge and acquire it independently – Present project results in an adequate written and oral form in a collaborative manner – Evaluate energy projects with regard to their economic viability and compare different variants
Competencies	– Transfer the knowledge they have acquired during their studies to a more complex, interdisciplinary problem/project task in the field of renewable energy systems – Develop various solutions to the problem/project task in a team and evaluate the solutions developed using suitable methods – Identify a preferred option from the solutions developed and defend it in front of stakeholders
Content	– Depending on the task – Mandatory: Fundamentals of investment calculation (LCOE / LCOH, CAPEX, OPEX)
Teaching format	Student project teams work on excerpts from an interdisciplinary planning or research project with a practical and energy-related focus. Supervisors provide specialist knowledge and specific boundary conditions through seminar-style teaching, which is then further developed by the students themselves.
Examination	Term paper with presentation
Media	Depending on the supervisor
Literature	Depending on the task

1.19 Module Engineering Studies 1

Module title Code	**Engineering Studies 1** M1-EngSt1
Duration / Frequency	One semester / Each semester
Responsible	All professors of the study programme
Lecturers	All professors of the study programme
Language	English
Workload	150 hours (45h Seminar, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	Master Geothermal Energy Systems
Learning goals Knowledge Skills Competencies	Students are able to work on engineering tasks within the framework of research projects under close supervision, document the results and communicate them. – Additional knowledge that goes beyond the knowledge acquired so far in the degree programme and is necessary for working on the research task – Understand, work on and find solutions to subtasks from research projects – Coordinate approaches with supervisors and peers – Research literature – Carry out experimental or numerical investigations – Document technical work in writing – Explain results orally to supervisors – Work independently and, where appropriate, in a team on a scientific task – Document results based on scientific work – Present results orally and answer critical questions confidently – Qualify for further involvement in research projects
Content	Depending on the task
Teaching format	As part of research projects, students are assigned subtasks and provided with explanations. The work is carried out individually or in small teams, closely supervised by seminar supervisors responsible for the research project. The results are documented in writing and presented to the responsible professors.
Examination	Term paper with presentation
Media	Not applicable
Literature	Depending on the task

1.20 Module Engineering Studies 2

Module title Code	**Engineering Studies 2** M1-EngSt2
Duration / Frequency	One semester / Each semester
Responsible	All professors of the study programme
Lecturers	All professors of the study programme
Language	English
Workload	150 hours (45h Seminar, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	Master Geothermal Energy Systems
Learning goals Knowledge Skills Competencies	Students are able to work on engineering tasks within the framework of research projects under close supervision, document the results and communicate them. – Additional knowledge that goes beyond the knowledge acquired so far in the degree programme and is necessary for working on the research task – Understand, work on and find solutions to subtasks from research projects – Coordinate approaches with supervisors and peers – Research literature – Carry out experimental or numerical investigations – Document technical work in writing – Explain results orally to supervisors – Work independently and, where appropriate, in a team on a scientific task – Document results based on scientific work – Present results orally and answer critical questions confidently – Qualify for further involvement in research projects
Content	Depending on the task
Teaching format	As part of research projects, students are assigned subtasks and provided with explanations. The work is carried out individually or in small teams, closely supervised by seminar supervisors responsible for the research project. The results are documented in writing and presented to the responsible professors.
Examination	Term paper with presentation
Media	Not applicable
Literature	Depending on the task

1.21 Module Engineering Measurement Technology

Module title Code	**Engineering Measurement Technology** M1-EngMT
Duration / Frequency	One semester / Each year in winter term
Responsible	Professorinnen und Professoren mit Labor
Lecturers	Participating professors who run a laboratory
Language	English
Workload	150 hours (45h Practica, 105h Self driven work)
Credit points / Contact time	5 Credit points / 3 Hours per week
Required prerequisites	According to current examination regulations
Recommended prerequisites	– Students should have previously attended a laboratory course. – Students should attend a suitable basic module for the chosen laboratory beforehand or in parallel.
Study programmes	Master Geothermal Energy Systems
Learning goals	Students can independently carry out experiments in the selected laboratories and analyse and assess the measurements using statistical methods. They are familiar with basic and in-depth experiments in the respective specialisation and can create detailed test reports.
Knowledge	– Test standards of the respective specialisation – Experimental setups of the respective specialisation
Skills	– Evaluation of measurement results in spreadsheet programmes – Analysing measurement results in Matlab or in Python (or similar) – Set up experiments – Carry out experiments – Document experimental results
Competencies	– Independent familiarisation with measurement regulations – Research of test standards – Selection of suitable evaluation methods – Interpretation of the measurement results – Preparation of test reports
Content	Test standards of the respective specialities
Teaching format	Lecture, exercises with data analysis software, practical course
Examination with elements	– Lab report – Course attendance certificate (Testat)
Media	– Blackboard – Digital projector
Literature	Corresponding test standards, GUM

1.22 Module Key Competences

Module title Code	**Key Competences** M1-KeyCom
Duration / Frequency	One semester / Each semester
Responsible	Dekanat
Lecturers	Lecturers of the BO Academy
Language	English
Workload	150 hours
Credit points	5 Credit points
Required prerequisites	According to current examination regulations
Recommended prerequisites	
Study programmes	Master Geothermal Energy Systems
Learning goals	With the exception of the English language courses, students are free to choose courses in key competences such as project management, rhetoric and presentation or intercultural communication from the elective courses offered by the BO Academy. The learning objectives are therefore derived from the BO Academy programme.
Content	Depending on the selected BO Academy course
Teaching format	Depending on the selected BO Academy course
Examination	Depending on the selected BO Academy course
Media	Depending on the selected BO Academy course
Literature	Depending on the selected BO Academy course

2 Modules in Second Study Year

Compulsory Modules

2.1 Master Thesis and Colloquium 26

2.1 Module Master Thesis and Colloquium

Module title	**Master Thesis and Colloquium**
Code	M2-MThes
Duration / Frequency	One semester / Each semester
Responsible	All professors of the study programme
Lecturers	All professors of the study programme
Language	English
Workload	900 hours
Credit points	30 Credit points
Required prerequisites	According to current examination regulations
Recommended prerequisites	All required elective modules
Study programmes	Master Geothermal Energy Systems
Learning goals	Students are able to work on engineering tasks in the area of renewable energy systems, document them and present them in a colloquium.
Knowledge	– Additional knowledge that goes beyond what has already been learnt during the study courses and is necessary for the processing of the thesis task.
Skills	– Applying specialised knowledge – Recognising and solving tasks – Develop solution strategies for new types of tasks – Document engineering work in writing – Research literature and use software – Programme own software if necessary
Competencies	– Work independently on complex tasks over an extended period of time. – Document the results based on scientific work – Present them orally, confidently answering critical questions. – Be prepared to compete for managerial positions in business or to pursue a PhD.
Content	Depending on the task
Teaching format	The Master's thesis should be written independently to the greatest extent. The supervising professors coordinate the task with the student and are available for supervision appointments. After the written thesis has been corrected, there is a final colloquium with a presentation.
Examination	Thesis with colloquium
Media	Not applicable
Literature	Depending on the task