Karlsruher Institut für Technologie

Module Handbook
Geophysics Master (M.Sc.)

SPO (Version) 2015

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KIT DEPARTMENT OF PHYSICS, GEOPHYSICAL INSTITUTE

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Prologue

Introduction

Karlsruhe Institute of Technology (KIT) has, as part of the implementation of the Bologna Process for the establishment of a European Higher Education Area, decided to provide a master's degree as the regular certificate at the end of its university studies. KIT therefore sees the consecutive bachelor's and master's degree programs offered as an overall concept with a consecutive curriculum. Students from other universities, who fulfil the requirements to study in KIT's master's program in Geophysics, are equally admitted.

The Study and Examination Regulations (SPO) of the master's program in Geophysics define a number of 120 ECTS credits for the successful completion of the master's program. Quality assurance is provided by a compulsory master thesis, with a working time of six months, awarded with 30 ECTS points. The regular study duration is four terms (two years) including the master thesis.

After completing the master's examination, a "Master of Science (M. Sc.)" is awarded by KIT.

Topics studied are grouped into subjects and those are divided into modules. All modules are listed in this module description within this module handbook. With this prologue we provide information that goes beyond the content of the module description. All information refers to the German version of the Study and Examination Regulations (SPO), as of 20.09.2015.

German SPO (legally binding):
http://www.gpi.kit.edu/downloads/Modulhandb%c3%bccher_%20SPO/SPO%20Master%20 2015%20Deutsch.pdf

English translation of German SPO (not legally binding):

http://www.gpi.kit.edu/downloads/Modulhandb%c3%bccher_%20SPO/SPO%20Master%20 2015%20English.pdf

Geophysics master's program at KIT

The consecutive master's program in Geophysics has - while retaining a broad range of expertise - a strongly deepening and profile-forming character. This is illustrated by the focus of the master's program in Applied Seismics, Seismology and Natural Hazards. The master's program thus has a close connection to practical issues and current research topics at the Geophysical Institute. Individual emphases can be set in the compulsory electives courses.

This profiling requires a solid basic education in the context of a bachelor's degree program. Accordingly, the Faculty of Physics has issued admission requirements. Missing fundamentals in Geophysics can be acquired in mandatory additional studies.

German admission requirements (legally binding):

http://www.gpi.kit.edu/downloads/Modulhandb%c3%bccher_%20SPO/2018_AB_009.pdf

English translation of German admission requirements (not legally binding):

http://www.gpi.kit.edu/downloads/Modulhandb%c3%bccher_%20SPO/English_translation_not_binding_Admissio.pdf

Of central importance is the master thesis, which is prepared by the “Scientific Focusing Phase” and the “Introduction to Scientific Practice”. There, key qualifications are acquired in an integrative manner (goal-oriented work, measurement technology, protocol management, teamwork, study of literature, formulation of scientific questions, defense of own work results, etc.). Additive key qualifications amounting to four ECTS (European Credit Transfer System) credits are acquired as part of the course offer of the KIT.

2 Qualification Objectives

Students of the Geophysics master's program know and understand the scientific basics of general and applied geophysics. The students understand the theory of seismic waves and can calculate the solution of the elastic wave equation for the general and special cases. They know the principles of inversion of seismic waves and can apply them. They understand measurement procedures used in geophysics, can explain and compare a variety of measurement principles and know how to perform an objective and detailed error analysis of the measurement results. They can process and analyse seismic signals of different frequency ranges and assess seismic analyses. In the field of reflection seismics and array seismology, students are familiar with the working steps from data acquisition to analysis and are able to carry them out on their own. Students who have obtained their bachelor's degree outside KIT may require to complete basic courses in the field of signal processing in compulsory electives, unless they have already acquired these qualifications in their previous studies.

The graduates understand geoscientific and physical contexts beyond the field of geophysics, they can discuss and interpret: Based on the acquired knowledge, they correctly classify topics and have the practical ability to solve tasks of geophysics and neighbouring geoscientific disciplines.

They have the ability, to deduce relationships from measured data, to formulate complex models, to derive predictions and to concretely verify or falsify them using advanced methods like inversion of data. Graduates can apply knowledge of geophysics to research-related questions and are able to analyse and solve technical problems using geophysical methods including software and hardware. Graduates have competences in clearly summarizing scientific results in written and spoken language and are able to present their work in a didactically appealing manner. The graduates can work independently and have extensive communicative and organizational skills.

3 Subjects

3.1 Geophysics

The core of the master's program is Geophysics with 40 ECTS credits. It includes the modules "Seismometry, Signal Processing and Seismogram Analysis" (winter term) and "Theory and Inversion of Seismic Waves" (summer term). From the beginning of the study in the winter or summer term, it depends on whether one or the other module is completed first. A start in the summer term (April) is not recommended for students from abroad or students who do not hold a bachelor degree in Geophysics. The module contents are taught in lectures and exercises as well as acquired in individual work. In the subject of Geophysics, a profile is formed according to the research foci of the Geophysical Institute. During the courses the students get to know the research areas of the institute. The lecturers facilitate the contact between students and scientists, regularly provide insights into current research and establish a close connection to current scientific issues in their courses.

3.2 Electives

In order to specialize the students can choose compulsory elective courses for individual profile-forming. Here, additional course offers in the field of geophysics as well as offers from the neighbouring disciplines (earth sciences, physics, engineering, etc.) can be selected and combined on an advanced level. The scope of the courses must sum up to a total of at least 16 ECTS credits. All examinations, which students wish to be credited in the compulsory elective courses and which are not selectable in the electronic examination system, must first be recognized by the Examination Committee.

At least eight ECTS points must be earned through graded examinations. The module grade is then calculated as ECTS-weighted average of the individual graded courses. For this purpose, all graded examinations are used for the formation of the technical grade. All other coursework and exams complete the list of not-graded courses until the total of 16 ETCS points have been reached. The exact nature and extent of the examinations will be announced by the corresponding lecturer at the beginning of the lecture period. Furthermore, the provisions of §8 of the Study and Examination Regulations apply to repeat examinations.

In order to have a course, graded or not-graded, counted for the compulsory electives, it must be individually appreciated. There is no fixed list of compulsory elective courses that are statically stored in the electronic examination system.

Therefore, the following procedure should be observed:

1. Choosing one or more courses for the compulsory electives.
2. An informal list of one or more courses will be checked and signed by the representative of the Examination Committee (Dr. Ellen Gottschämmer). The list can be found here: http://www.gpi.kit.edu/downloads/Genehmigung_Wahlpflichtfaecher_MSc.pdf

3. Download of a “blue form” for each individual course. The top box is to be filled out by the student. A “blue form” can be found here: https://www.sle.kit.edu/downloads/Sonstige/Pruefungszulassung-Erstversuch.pdf

4. This “blue form” will be handed over to the examiner of the compulsory elective course.
5. After successfully passing the exam or coursework, the “blue form” will be sent by the examiner back to the Examination Office of the Faculty of Physics, where the graded or not-graded result will be entered into the electronic examination system.

3.3 Interdisciplinary Qualifications

In addition to the subject-specific qualifications, at least four ECTS credits must be acquired in interdisciplinary qualifications (also known as professional skills or additive key competences). The corresponding modules from the fields of scientific English, patent law, project management, tutorials, scientific writing or public science are offered by the HoC, ZAK, and the SpZ at KIT. Other modules require the approval of the Examination Committee.

The certificates of the interdisciplinary qualifications are not graded. Graded offers can be selected but do not contribute to the overall grading. The exact nature and extent of the examinations will be announced by the corresponding lecturer at the beginning of the lecture period. Furthermore, the provisions of §8 of the Study and Examination Regulations apply to repeat examinations.

3.4 Introduction to Scientific Practice and Scientific Focusing Phase and Master Thesis

The actual work on the master thesis is preceded by the subjects “Scientific Focusing Phase” and “Introduction to Scientific Practice”. In both subjects sound foundations and key qualifications (in integrative form) for scientific work are taught as preparation for the master thesis itself.

In the subject “Introduction to Scientific Practice” students learn basic working methods that are required for successful scientific research. The working methods themselves are independent of a scientific field, but are practiced and learned on the basis of a specific task (topic of the master thesis). The students will be guided by the future supervisor of the master thesis. As a result, the students submit a written report, which shows that they have adopted the scientific working methods and applied them to the topic of their future master thesis. In addition, students attend seminars and colloquia accompanying geophysics, geosciences, and physics. Students gain an overview of current research topics, learn to follow scientific presentations that are outside their area of specialization, and expand their knowledge through appropriate questions to the lecturers.

In the subject “Scientific Focusing Phase” the students independently work on a specific task that is related to the future master thesis. This can be, for instance, performing measurements or creating a computer program or developing a theoretical approach. In this way, the students learn guided by the future supervisor of the master thesis essential working techniques for the processing of their master thesis, which are specific to the corresponding scientific field. The students will attend the seminar of the research area in which they will prepare their master thesis. In this seminar, they present their work and put their work results to critical discussion. They learn to present their work to third parties and to include suggestions from the scientific discussion for the further proceeding.

Registration: At the beginning of the second year, once the students have found a topic to work on during the subjects “Introduction to Scientific Practice”, “Scientific Focusing Phase” and during the module “Master thesis”, students need to visit the Examination Office of the Faculty of Physics. There, they will get a form signed with which students register for their topic. This form is either found in the downloads’ sections of our webpage and can be printed by the students themselves, or it can be obtained by our secretary offices (Ms Payne, Ms Dick) at GPI, and it can also be obtained in the Examination Office itself. It will be signed by the Examination Office in case the students fulfil all requirements. This form then has to be handed over to the reviewer of the thesis by the student. The reviewer needs to fill in the required fields (start date: 12 months before intended submission) and send the form back to the Examination Office. In parallel, students have to register for all modules in the above mentioned subjects electronically in Campus. For the Master thesis itself, there is no additional registration necessary.

The master thesis is a central component of profiling and deepening. As part of the master thesis, the students demonstrate that they can independently analyse a scientific problem under guidance, develop suitable solutions, interpret the results and present the whole in a written document. These are important interdisciplinary skills for any future job. The results of the master thesis are presented in a faculty-public colloquium.

A master thesis may only be awarded by examiners according to §17 (2) of the Study and Examination Regulations. It can be carried out as project work in one of the working groups of the faculty or corresponding groups at the KIT. It is also possible to realize an external master thesis outside the faculty. To do this, a supervisor from the faculty must be found who is willing to support the external work and obtain the approval of the Examination Committee. A written document is to be prepared on the topic of the master thesis. Both the supervisor and the second reviewer each receive a printed and bound copy of the work. In addition, one copy each is to be handed to the examination office of the faculty (exam copy, signed by the supervisor) and to the library of the Geophysical Institute.

4 Registration for examinations

Registration is online via the central examination system of the KIT. Examinations and coursework are the evaluated review of achieving the qualification objectives defined in the module. They are subject-specific, didactically coordinated and immediate. Examinations are written, oral or of other type. Coursework is not-graded reviews and are often required as a prerequisite for examinations.

According to §6 of the Study and Examination Regulations, the actual type of assessment is announced for a module examination in the module handbook. The conditions under which a repetition of written and oral examinations is possible are specified in §8 of the Study and Examination Regulations.

5 Grade

The overall grade of the master's examination is calculated as an average grade weighted by credit points. The subject Geophysics and the compulsory elective subject are weighted with their credit points and the module master thesis is weighted with twice the number of credit points.

6 Module scheme

The tabular module scheme shows the distribution of the modules and the courses they contain within the terms of the study program. The overview of the workload for the degree program is shown in ECTS points. An ECTS point corresponds to a workload of 30 hours.

Subject: Term/Semester	Geophysics		Scientific Focusing Phase	Introduction to Scientific Practice		Compulsory Elective	SQs	CPs
1 (WS)	**Module: Seismometry, Signal Processing and Seismogram Analysis**							
SWS CPs	Physics of Seismic Instruments V2 Ü1 6	Seismology V2 Ü2 8				Compulsory Electives 6	SQs I 2	
SWS CPs		Seismics V2 Ü2 8						
Sum CPs		**22**				**6**	**2**	**30**
2 (SS)	**Module: Theory and Inversion of Seismic Waves**							
SWS CPs	Theory of Seismic Waves V2 Ü1 6	Inversion and Tomography V2 Ü2 8				Compulsory Electives 10	SQs II 2	
SWS CPs	Seismic Modelling V1 Ü1 4							
Sum CPs		**18**				**10**	**2**	**30**
3 (WS)			**Module: Scientific Focusing Phase**	**Module: Introduction to Scientific Practice**				
SWS CPs			Seismic/Seismology Seminar S 2 10	Introduction to Research in a Scientific Sub-Field Including a Seminar paper 16				
				Module: Scientific Seminars				
SWS CPs				Seminar of the Geophysical Institute/ Phys. Colloquium/etc. S 2 4				
Sum CPs			**10**	**20**				**30**
4 (SS)					**Module: Master Thesis**			
SWS CPs					Masterthesis and Colloquium 30			
Sum CPs					**30**			**30**
Sum CPs		**40**	**10**	**20**	**30**	**16**	**4**	**120**
							Sum:	**120**

2 Field of study structure

Mandatory	
Master Thesis	30 CR
Geophysics	40 CR
Electives	16 CR
Scientific Focusing Phase	10 CR
Introduction to Scientific Practice	20 CR
Interdisciplinary Qualifications	4 CR
Voluntary	
Additional Examinations	

2.1 Master Thesis

Credits
30

Mandatory		
M-PHYS-101730	Modul Master Thesis	30 CR

2.2 Geophysics

Credits
40

Mandatory		
M-PHYS-101358	Seismometry, Signal Processing and Seismogram Analysis	22 CR
M-PHYS-101359	Theory and Inversion of Seismic Waves	18 CR

2.3 Electives

Credits
16

Election block: Wahlbereich (at least 16 credits)		
M-BGU-101030	Recent Geodynamics	4 CR
M-PHYS-101355	Modern Physics Laboratory Course	6 CR
M-PHYS-101833	Geological Hazards and Risk	8 CR
M-PHYS-101878	Induced Seismicity, not graded	3 CR
M-BGU-101996	Structural Geology and Tectonics	4 CR
M-PHYS-101866	Introduction to Volcanology, graded	4 CR
M-PHYS-101870	The Black Forest Observatory at Schiltach	1 CR
M-PHYS-101871	Measuring Methods in Physical Volcanology, not graded	1 CR
M-PHYS-101872	Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, not graded	3 CR
M-PHYS-101873	Hazard and Risk Assessment of Mediterranean Volcanoes, graded	6 CR
M-PHYS-101874	Geophysical Investigation of Volcanic Fields, not graded	3 CR
M-PHYS-101875	Physics of the Lithosphere, not graded	2 CR
M-PHYS-101944	Introduction to Volcanology, not graded	3 CR
M-PHYS-101946	Near Surface Geophysical Prospecting	1 CR
M-PHYS-101950	Measuring Methods in Physical Volcanology, graded	2 CR
M-PHYS-101951	Geophysical Investigation of Volcanic Fields, graded	4 CR
M-PHYS-101952	Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, graded	4 CR
M-PHYS-101953	Hazard and Risk Assessment of Mediterranean Volcanoes, not graded	4 CR
M-PHYS-101959	Induced Seismicity, graded	5 CR
M-PHYS-101960	Physics of the Lithosphere, graded	3 CR
M-PHYS-101961	Historical Seismology for Hazard Evaluation	1 CR
M-PHYS-103142	Module Wildcard Electives	16 CR
M-PHYS-103141	Geophysical Monitoring of Tunnel Constructions	1 CR
M-PHYS-103145	Black Forest Observatory Course	1 CR
M-PHYS-103803	Seminar on recent topics of risk science	4 CR
M-PHYS-101354	Classical Physics Laboratory Course II	6 CR
M-PHYS-103855	Near-surface seismic and GPR	6 CR
M-PHYS-103856	3D reflection seismics	1 CR
M-PHYS-103914	Geodynamic Modelling I	2 CR
M-PHYS-103915	Geodynamic Modelling II	2 CR
M-PHYS-104186	Seismic Data Processing with final report (graded)	6 CR
M-PHYS-104188	Seismic Data Processing with final report (ungraded)	6 CR
M-PHYS-104189	Seismic Data Processing without final report (ungraded)	2 CR
M-PHYS-104195	In-Situ: Seismic Hazard in the Apennines	6 CR
M-PHYS-104196	In-Situ: Summer School Bandung: Seismology/Geohazards	6 CR
M-PHYS-104522	Full-waveform Inversion, not graded	6 CR
M-PHYS-105235	Full-waveform inversion, graded *First usage possible from 10/1/2019.*	6 CR

2.4 Scientific Focusing Phase

Credits
10

Mandatory		
M-PHYS-101360	Scientific Focusing Phase	10 CR

2.5 Introduction to Scientific Practice

Credits
20

Mandatory		
M-PHYS-101357	Scientific Seminars	4 CR
M-PHYS-101361	Introduction to Scientific Practice	16 CR

2.6 Interdisciplinary Qualifications

Credits
4

Mandatory		
M-PHYS-102349	Interdisciplinary Qualifications	4 CR

2.7 Additional Examinations

Election block: Zusatzleistungen (at most 30 credits)		
M-PHYS-102020	Further Examinations	30 CR

3 Modules

M 3.1 Module: 3D reflection seismics [M-PHYS-103856]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Irregular	English	4	1

Mandatory			
T-PHYS-107806	3D reflection seismics	1 CR	Bohlen, Hertweck

Competence Goal
The students refresh and elaborate their knowledge of reflection seismics. They comprehend the fundamentals of seismic data acquisition and learn about practical issues relevant in the field. They participate a field experiment and get to know hardware, procedures used in the field, and relevant people and positions in the field. In the end, students will be familiar with the basics of running field acquisition and collecting land seismic data. They deepen their knowledge of the reflection seismic principles and have a good understanding of practical issues. They are able to apply the principles to other seismic surveys and analyse important field parameters. They comprehend how theory of wave propagation and signal processing relates to practice andthe influence it has onthe field acquisition setup.

Prerequisites
None

Content

- Introduction to 3D reflection seismic
- Land acquisition and land-specific issues
- Field trip and in-situ lecture (1 day):
  a) Introduction to the geological background (handled by colleagues from Rhein Petroleum
  b) Equipment, acquisition procedures, data quality control
- Wrap-up and summary

Recommendation
Understanding of the basic reflection seismic principles.

M 3.2 Module: Black Forest Observatory Course [M-PHYS-103145]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Each winter term	English	4	4

Mandatory			
T-PHYS-106261	Black Forest Observatory Course	1 CR	Forbriger

Competence Certificate
Active participation in experiments and data analysis is mandatory.

Competence Goal
The students are able to install and adjust a broad-band seismometer. They understand and can apply basic steps of data quality assessment. The students understand methods to calibrate the instruments frequency response and gain. They are able to carry out and analyse calibration experiments.

Module grade calculation
The coursework is not graded.

Prerequisites
One of the courseworks:

T-PHYS-102325 - Physics of Seismic Instruments, Prerequisite (MSc Geophysics)

T-PHYS-104727 - Physics of Seismic Instruments (MSc Physics)

T-PHYS-105567 - Physics of Seismic Instruments (NF) (MSc Physics)

Modeled Conditions
You have to fulfill one of 3 conditions:

1. The course T-PHYS-104727 - Physics of Seismic Instruments must have been passed.
2. The course T-PHYS-105567 - Physics of Seismic Instruments (Minor) must have been passed.
3. The course T-PHYS-102325 - Physics of Seismic Instruments, Prerequisite must have been passed.

Content

- Practical application of knowledge gained in the course on 'Physics of seismic instruments'
- In-situ experiments with force-balance feedback broad-band seismometers
- Installation and calibration of instruments
- Quantitative data analysis, comparison with observatory recordings, and data quality assessment
- The actual program will be discussed an planned on-site together with the participants

Workload
The course will be held on three entire days at the Black Forest Observatory.

Learning type
4060914 Observatoriumspraktikum (P2)

Literature
Bormann, P., (ed.), 2012. New Manual of Seismological Observatory Practice.
2nd edition. GeoForschungsZentrum Potsdam. DOI: 10.2312/GFZ.NMSOP-2.
http://dx.doi.org/10.2312/GFZ.NMSOP-2
Chapter 5, information sheets and exercises on seismometer calibration
in particular.

M 3.3 Module: Classical Physics Laboratory Course II [M-PHYS-101354]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Duration	Language	Level	Version
6	Each summer term	1 term	German	4	1

Mandatory			
T-PHYS-102290	Classical Physics Laboratory Courses II	6 CR	Quast, Simonis

Prerequisites
none

3.4 Module: Full-waveform inversion, graded [M-PHYS-105235]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Electives (Usage from 10/1/2019)

Credits	Recurrence	Language	Level	Version
6	Irregular	English	4	1

Mandatory			
T-PHYS-110614	Full-waveform inversion (graded)	6 CR	Bohlen

Competence Certificate
To pass the module, successful participation in the exercises is required. Students have to write a report on a special exercise at the end of the lecture period. This report is graded.

Competence Goal
The students know the fundamentals about full-waveform inversion from theory to practical implementation. They understand the basic concept of full-waveform inversion and grid-based finite-difference schemes to solve the wave equation. They understand important practical aspects such as numerical effects and critical performance issues. Students are able to implement a basic full-waveform inversion algorithm and apply it to simple data sets. They can analyze important factors influencing the success of full-waveform inversion and assess the quality of inversion results.

Module grade calculation
The grade of the module is the grade of the written report on the special exercise at the end of the lecture periode.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104522 - Full-waveform Inversion, not graded must not have been started.

Content

- Introduction to full-waveform inversion (FWI)
- Solution of the wave equation with the finite-difference method
- Practical issues and numerical effects
- Adjoint-state method
- Adaption of the adjoint-state method for FWI
- FWI of shallow seismic wavefields

Recommendation
Knowledge of differential calculus is essential. Experience with Matlab and general computer skills are beneficial.

Learning type
4060181Seismic Full Waveform Inversion (V2)
4060182 Exercises to Seismic Full Waveform Inversion (Ü1)

Literature

- Andreas Fichtner, "Full Seismic Waveform Modelling and Inversion", 2011, Springer.

3.5 Module: Full-waveform Inversion, not graded [M-PHYS-104522]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Irregular	English	4	2

Mandatory			
T-PHYS-109272	Full-waveform inversion	6 CR	Bohlen, Hertweck

Competence Certificate
Final pass based on successful participation of the exercises.

Competence Goal
The students know the fundamentals about full-waveform inversion from theory to practical implementation. They understand the basic concept of full-waveform inversion and grid-based finite-difference schemes to solve the wave equation. They understand important practical aspects such as numerical effects and critical performance issues. Students are able to implement a basic full-waveform inversion algorithm and apply it to simple data sets. They can analyze important factors influencing the success of full-waveform inversion and assess the quality of inversion results.

Module grade calculation
The coursework is not graded.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-105235 - Full-waveform inversion, graded must not have been started.

Content

- Introduction to full-waveform inversion (FWI)
- Solution of the wave equation with the finite-difference method
- Practical issues and numerical effects
- Adjoint-state method
- Adaption of the adjoint-state method for FWI
- FWI of shallow seismic wavefields

Recommendation
Knowledge of differential calculus is essential. Experience with Matlab and general computer skills are beneficial.

Learning type
4060181Seismic Full Waveform Inversion (V2)
4060182 Exercises to Seismic Full Waveform Inversion (Ü1)

Literature

- Andreas Fichtner, "Full Seismic Waveform Modelling and Inversion", 2011, Springer.

M 3.6 Module: Further Examinations [M-PHYS-102020]

Organisation: KIT Department of Physics
Part of: Additional Examinations

Credits	Recurrence	Language	Level	Version
30	Each term	German	4	1

Election block: Zusatzleistungen (at most 30 credits)			
T-PHYS-103898	Wildcard Additional Examinations 1	2 CR	
T-PHYS-103937	Wildcard Additional Examinations 11	2 CR	

M 3.7 Module: Geodynamic Modelling I [M-PHYS-103914]

Responsible: Dr. Oliver Heidbach
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
2	Each winter term	English	4	2

Mandatory			
T-PHYS-107998	Geodynamic Modelling I	2 CR	Heidbach

Competence Certificate
Presentation at the end of the block course

Competence Goal
The students have acquired basic knowledge about the stress tensor and how to estimate the individual components of the stress tensor with stress indicators, such as e.g. earthquake focal mechanisms or borehole breakouts. They are able to derive the partial differential equation of the equilibrium of forces and master the fundamental steps in the course of a geomechanical-numerical modelling. The students are able to investigate a working hypothesis by building a model to investigate it. They are able to argue why their model approach is appropriate and to critically assess others' model approaches by analysing the model assumptions, boundary and initial conditions.

Module grade calculation
The module is not graded.

Prerequisites
None

Content
I. Basics theory of the 3D stress tensor

- formalism and definition of tectonic stress
- stress indicators
- World Stress Map database

II. Applications

- Earthquake cycle and tectonic processes
- Stability of underground mining and repositories
- Economic aspects in oil, natural gas reservoirs, and geothermal energy

III. Fundamentals of geomechanical modelling

- Definition of the term “modelling”
- Key steps on the course of “modelling”
- Outlook on numerical solution methods

Learning type
4060141Geodynamische Modellierung I (V2)

Literature
Literature provided by the supervisor

M 3.8 Module: Geodynamic Modelling II [M-PHYS-103915]

Responsible: Dr. Oliver Heidbach
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
2	Each winter term	English	4	2

Mandatory			
T-PHYS-107999	Geodynamic Modelling II	2 CR	Heidbach

Competence Certificate
Presentation at the end of the block course

Competence Goal
The students know the basic concepts that play a role in this modelling and are able to investigate a working hypothesis with a model. They understand the basic knowledge of the Finite Element Method (FEM) and are familiar with the numerical uncertainties that are made with the discretization of model space. Students are able to create simple geomechanical 3D models, discretize the volume, find a numerical solution with the FEM and visualize scalar and vectorial values of the stress tensor and displacements, and assess the results in the context of the hypothesis.

Module grade calculation
The module is not graded.

Prerequisites
M-PHYS-103914 – Geodynamic Modelling I

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-103914 - Geodynamic Modelling I must have been passed.

Content
I. Fundamentals of Modelling

- Process of modelling
- Rheology and temperature field
- Analytical solutions

II. Theory of the Finite Element Method (FEM)

- Discretization of the model volume
- Basic principles of the FEM
- Differences to the finite difference and the boundary element method
- Boundary and initial conditions

III. Practice

- Introduction to the commercial codes Abaqus and Hypermesh
- Simulations on the computer
- Visualization of the stress tensor and displacement results with Tecplot 360 EX

Learning type
4060291 Geodynamische Modellierung II (V2)

Literature
Literature provided by the supervisor

M 3.9 Module: Geological Hazards and Risk [M-PHYS-101833]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
8	Each winter term	English	4	4

Mandatory			
T-PHYS-103525	Geological Hazards and Risk	8 CR	Gottschämmer

Competence Certificate
Active and regular attendance of lecture and practicals. Project work (graded).

Competence Goal
The students understand basic concepts of hazard and risk. They can explain in detail different aspects of earthquake hazard, volcanic hazard as well as other geological hazards, can compare and evaluate those hazards. The have fundamental knowledge of risk reduction and risk management. They know methods of risk modelling and are able to apply them.

Module grade calculation
Project work will be graded.

Prerequisites
none

Content

- Earthquake Hazards
    - Short introduction to seismology and seismometry (occurrence of tectonic earthquakes, types of seismic waves, magnitude, intensity, source physics)
    - Induced seismicity
    - Engineering seismology, Recurrence intervals, Gutenberg-Richter, PGA, PGV, spectral acceleration, hazard maps
    - Earthquake statistics
    - Liquefaction
- Tsunami Hazards
- Landslide Hazards
- Hazards from Sinkholes
- Volcanic Hazards
    - Short introduction to physical volcanology
    - Types of volcanic hazards
- The Concept of Risk, Damage and Loss
- Data Analysis and the use of GIS in Risk analysis
- Risk Modelling - Scenario Analysis
- Risk Reduction and Risk Management
- Analysis Feedback and Prospects in the Risk Modelling Industry

Workload

- 60 h: active attendance during lectures and exercises
- 90 h: review, preparation and weekly assignments
- 90 h: project work

Learning type

4060121 Geological Hazards and Risk (V2)

4060122 Übungen zu Geological Hazards and Risk (Ü2)

Literature

Literature will be provided by the lecturer.

M 3.10 Module: Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, graded [M-PHYS-101952]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Irregular	German	4	1

Mandatory			
T-PHYS-103571	Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, Studienleistung	3 CR	Gottschämmer
T-PHYS-103673	Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, exam	1 CR	Gottschämmer

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101872 - Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, not graded must not have been started.

3.11 Module: Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, not graded [M-PHYS-101872]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
3	Irregular	German	4	1

Mandatory			
T-PHYS-103571	Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, Studienleistung	3 CR	Gottschämmer

Modeled Conditions
The following conditions have to be fulfilled:

1. The module **M-PHYS-101952 - Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, graded** must not have been started.

3.12 Module: Geophysical Investigation of Volcanic Fields, graded [M-PHYS-101951]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Irregular	German	4	1

Mandatory			
T-PHYS-103573	Geophysical Investigation of Volcanic Fields, Prerequisite	3 CR	Ritter
T-PHYS-103672	Geophysical Investigation of Volcanic Fields, exam	1 CR	Ritter

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101874 - Geophysical Investigation of Volcanic Fields, not graded must not have been started.

M 3.13 Module: Geophysical Investigation of Volcanic Fields, not graded [M-PHYS-101874]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
3	Irregular	German	4	1

Mandatory			
T-PHYS-103573	Geophysical Investigation of Volcanic Fields, Prerequisite	3 CR	Ritter

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101951 - Geophysical Investigation of Volcanic Fields, graded must not have been started.

M 3.14 Module: Geophysical Monitoring of Tunnel Constructions [M-PHYS-103141]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Irregular	German	4	1

Mandatory			
T-PHYS-106248	Geophysical Monitoring of Tunnel Constructions, Prerequisite	1 CR	Gottschämmer

M 3.15 Module: Hazard and Risk Assessment of Mediterranean Volcanoes, graded [M-PHYS-101873]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Irregular	German	4	1

Mandatory			
T-PHYS-103572	Hazard and Risk Assessment of Mediterranean Volcanoes, Prerequisite	4 CR	Gottschämmer
T-PHYS-103674	Hazard and Risk Assessment of Mediterranean Volcanoes, exam	2 CR	Gottschämmer

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101953 - Hazard and Risk Assessment of Mediterranean Volcanoes, not graded must not have been started.

M 3.16 Module: Hazard and Risk Assessment of Mediterranean Volcanoes, not graded [M-PHYS-101953]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Irregular	German	4	1

Mandatory			
T-PHYS-103572	Hazard and Risk Assessment of Mediterranean Volcanoes, Prerequisite	4 CR	Gottschämmer

Modeled Conditions
The following conditions have to be fulfilled:

1. The module **M-PHYS-101873 - Hazard and Risk Assessment of Mediterranean Volcanoes, graded** must not have been started.

M 3.17 Module: Historical Seismology for Hazard Evaluation [M-PHYS-101961]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Irregular	German	4	1

Mandatory			
T-PHYS-103679	Historical Seismology for Hazard Evaluation, Prerequisite	1 CR	Gottschämmer

3.18 Module: Induced Seismicity, graded [M-PHYS-101959]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
5	Irregular	English	4	2

Mandatory			
T-PHYS-103575	Induced Seismicity, Studienleistung	3 CR	Ritter
T-PHYS-103677	Induced Seismicity, exam	2 CR	Ritter

Competence Certificate
Presentation (45%), report (45%) and participation in discussion (10%) will be graded. A detailed rating scheme will be distributed during the first lecture.

Competence Goal
The students understand physical and tectonic causes and effects of induced seismicity, and they are able to explain its occurrence. They have gained basic knowledge of legal aspects associated with induced seismicity. They are able to distinguish between different physical sources of induced seismicity and can analyse seismicity caused by the loading of dams, due to mining, and associated with geothermal energy exploitation. The students know and are able to name regions, where induced seismicity occurs and can identify structures that may indicate the possible occurrence of induced seismicity in the field.
The students are able to work self-organized on a specific issue of induced seismicity. They are able to read and understand technical literature about the topic. They can outline and analyse the problem, and they are able to critically discuss the content of technical literature with their peers and present their own point of view. They can summarise the problem, and interpret and evaluate the content of technical literature on the topic of induced seismicity.

Module grade calculation
Presentation (45%), report (45%) and participation in discussion (10%) will be graded. A detailed rating scheme will be distributed during the first lecture.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101878 - Induced Seismicity, not graded must not have been started.

Content

- Fundamentals of Induced Seismicity
- Cause and Effect of Induced Seismicity
- Legal Aspects
- Case Studies: Dams, Mining, Geothermal Energy
- Field Trips to a Geothermal Energy Plant, to a Mining Region in Germany and to a dam

Workload
Total workload: 150 h which consists of

- 10 h lecture at KIT as preparation
- 5 h preparation and wrap-up of lecture
- 40 h in situ lecture in Thuringia
- 35 h preparation of presentation
- 60 h preparation of report

3.19 Module: Induced Seismicity, not graded [M-PHYS-101878]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
3	Irregular	English	4	1

Mandatory			
T-PHYS-103575	Induced Seismicity, Studienleistung	3 CR	Ritter

Competence Certificate
In order to pass the module a presentation has to be given during the in situ lecture and participation in discussions after presentations of fellow students is necessary.

Competence Goal
The students understand physical and tectonic causes and effects of induced seismicity, and they are able to explain its occurrence. They have gained basic knowledge of legal aspects associated with induced seismicity. They are able to distinguish between different physical sources of induced seismicity and can analyse seismicity caused by the loading of dams, due to mining, and associated with geothermal energy exploitation. The students know and are able to name regions, where induced seismicity occurs and can identify structures that may indicate the possible occurrence of induced seismicity in the field.
The students are able to work self-organized on a specific issue of induced seismicity. They are able to read and understand technical literature about the topic. They can outline and analyse the problem, and they are able to critically discuss the content of technical literature with their peers and present their own point of view. They can summarise the problem, and interpret and evaluate the content of technical literature on the topic of induced seismicity.

Module grade calculation
The module is not graded.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101959 - Induced Seismicity, graded must not have been started.

Content

- Fundamentals of Induced Seismicity
- Cause and Effect of Induced Seismicity
- Legal Aspects
- Case Studies: Dams, Mining, Geothermal Energy
- Field Trips to a Geothermal Energy Plant, to a Mining Region in Germany and to a dam

Workload
Total workload: 90 h which consists of

- 10 h lecture at KIT as preparation
- 5 h preparaton and wrap-up of lecture
- 40 h in situ lecture in Thuringia
- 35 h preparation of presentation

M 3.20 Module: In-Situ: Seismic Hazard in the Apennines [M-PHYS-104195]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Irregular	German	4	1

Mandatory			
T-PHYS-108690	In-Situ: Seismic Hazard in the Apennines	6 CR	Gottschämmer

M 3.21 Module: In-Situ: Summer School Bandung: Seismology/Geohazards [M-PHYS-104196]

Responsible: Dr. Ellen Gottschämmer
Prof. Dr. Andreas Rietbrock

Organisation: KIT Department of Physics

Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Irregular	English	4	1

Mandatory			
T-PHYS-108691	In-Situ: Summer School Bandung: Seismology/Geohazards	6 CR	Gottschämmer, Rietbrock

Competence Certificate
The students receive a scientific paper to discuss in an international group of students regarding one of the above topics. They give a presentation about the paper (20 minutes plus 10 minutes of discussion) and write a summary (5-10 pages). The summary has to be handed in individually by every student two weeks after the end of the summer school and will be graded.

Competence Goal
The students know about the geology and tectonics of Indonesia and surrounding regions. They understand the processes and stress distributions that led to the formation of the Indonesian archipelago and know methods to model those.

The students can explain how earthquakes sources are represented and know about the distribution and characteristics of earthquakes. They understand the concept of seismic sources and stresses and can explain basic concepts of earthquake geology. They are familiar with seismic data acquisition systems and seismic array techniques. They understand the idea behind seismic tomography methods and know applications on global as well as regional and local scale.

The students understand the concepts of physical volcanology and can name the processes that are responsible for volcanic hazard and risk. They know methods of volcano seismology, can explain several modeling techniques and know about monitoring volcanoes at observatories using different geophysical techniques.

The students know about tsunami and flooding hazard and understand basic concepts of disaster management. The students understand basic concepts of geothermal energy and its exploitation.

Module grade calculation
Students give a presentation (group work) about a scientific paper and write a report about it. The report is graded.

Prerequisites
none

Content
Geology and Tectonics

- Geological Setting of Indonesia
- Visit to the Geological Museum, Bandung
- Introduction to Stress Modeling in Active Tectonic

Seismology, Seismic Hazard

- Introduction to Geohazards: Earthquake Hazard and Risk
- Distribution and Characteristic of Earthquakes
- Seismic sources and stresses
- Earthquake Geology
- Data acquisition and arrays
- Seismic Travel Time Tomography: Regional and Global Scale
- Local Earthquake Tomography
- Passive and active seismic imaging by seismic wave propagation modeling

Volcanology, Volcanic Hazard

- Physical Volcanology
- Volcanic hazard risk and assessment
- Volcano Seismology
- Modeling of Volcanic Products
- Visit of Guntur Volcano Observatory
- Visit to Tangkuban Parahu Volcano
- Visit to Center of Volcanology and Geological Hazard Mitigation

Tsunamis and Flooding Hazard

- Tsunamis: Generation, Inundation and Propagation
- Tsunamis: Hazard, Inundation and Warning
- Flood Hazard

Introduction to Disaster Management

Geothermal Systems

- Introduction to Geothermal system & Geology of Kamojang Field
- Visit of Kamojang

Workload
Total workload: 180 h, further details will be given in the lecture.

Learning type
4060351 - In-Situ: Summer School Seismology (Lecture)

4060352 - In-Situ: Summer School Seismology (Practicals)

Literature
Will be announced during the lecture.

M 3.22 Module: Interdisciplinary Qualifications [M-PHYS-102349]

Responsible: Dr. Andreas Barth
Organisation: KIT Department of Physics
Part of: Interdisciplinary Qualifications

Credits	Language	Level	Version
4	German	4	1

Election block: Wahlbereich (at least 1 item as well as at least 4 credits)			
T-PHYS-104675	Wildcard	2 CR	
T-PHYS-104677	Wildcard	2 CR	

3.23 Module: Introduction to Scientific Practice (GEOP M EWA) [M-PHYS-101361]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: Introduction to Scientific Practice

Credits	Recurrence	Duration	Language	Level	Version
16	Each term	1 term	English	4	2

Mandatory			
T-PHYS-103355	Introduction to Research in a Scientific Sub-Field Including a Seminar Paper	16 CR	

Competence Goal
The students are familiarized with the topic of their master thesis. They acquired key qualifications in an integrative manner and are able to implement them. The students know basic working methods that are required for successful scientific research and are able to apply them on the basis of a specific task (topic of the master thesis).

Module grade calculation
The module is not graded.

Content

- goal-oriented work
- measurement technology
- protocol management
- teamwork
- study of literature
- formulation of scientific questions
- defense of own work results

Workload
The students submit a written report (synopsis) on the topic of their future master thesis, which shows that they have adopted the scientific working methods and the task of their work. Total workload: 480 h.

Learning type
4061909 Einführung in die selbständige wissenschaftliche Arbeit

Literature
Task-specific, literature provided by the supervisor

3.24 Module: Introduction to Volcanology, graded [M-PHYS-101866]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Each summer term	English	2	2

Mandatory			
T-PHYS-103553	Introduction to Volcanology, Prerequisite	3 CR	Gottschämmer
T-PHYS-103644	Introduction to Volcanology, Exam	1 CR	Gottschämmer

Competence Certificate
Prerequisite (3 ECTS): Active and regular attendance of lecture and practicals, preparation and follow-up of lectures (at home), assignments, presentation of a volcano in a short (10 – 15 minute) talk with slides. Examination (1 ECTS): Scientific essay about the given presentation, approx. 8-10 pages, submitted electronically. The grade of the module results from grade of of the scientific essay.

Competence Goal
The Students know and understand the basic concepts of physical volcanology. They are able to classify volcanoes by their tectonic location, can discriminate between different eruption types and describe different volcanic edifices with respect to their tectonic environment. They understand the concept of volcanic hazard and risk and are able to apply it. They can explain the physics of volcanic monitoring methods and know about their advantages and disadvantages. They gained insight into numerical modelling tools and can name several appliations. The students understand the impact of volcanic eruptions on climate and know both, presently as well as historically active volcanoes and their prominent eruptions.

The students have gained an overview about active volcanoes and recent eruptions and are able to summerize the main characteristics and scientific achievements about one volcano of their choice in a 10-15 minute talk. They are able to discuss and answer questions related to their subject. They can summarize their research about the volcano of their choice in a scientific essay (8-10 pages).

Module grade calculation
The grade of the module results from grade of of the scientific essay.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101944 - Introduction to Volcanology, not graded must not have been started.

Content

- Introduction, Overview
- Volcanoes and Plate Tectonics
- Magma and Volcanic Deposits
- Eruption types
- Volcanic Edifices
- Volcanic Hazard and Risk
- Volcano Monitoring
- Volcano Seismology
- Numerical Modelling of Volcanic Products
- Historic Eruptions
- Volcanoes and Climate

Workload
28 h: Attendance, active participation in lectures and practicals

14 h: Preparation and follow-up of lectures (at home)

18 h: Homework, assignments

30 h: Preparation of presentation

30 h: Scientific essay about given presentation, submitted electronically

Learning type
4060251 Introduction to Volcanology (V1)
4060252 Exercises to Introduction to Volcanology (Ü1)

Literature
Literature will be provided by the lecturer.

M 3.25 Module: Introduction to Volcanology, not graded [M-PHYS-101944]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
3	Each summer term	English	4	3

Mandatory			
T-PHYS-103553	Introduction to Volcanology, Prerequisite	3 CR	Gottschämmer

Competence Certificate
Active and regular attendance of lecture and practicals, presentation of a volcano in a short (10 – 15 minute) talk with slides.

Competence Goal
The students know and understand the basic concepts of physical volcanology. They are able to classify volcanoes by their tectonic location, can discriminate between different eruption types and describe different volcanic edifices with respect to their tectonic environment. They understand the concept of volcanic hazard and risk and are able to apply it. They can explain the physics of volcanic monitoring methods and know about their advantages and disadvantages. They gained insight into numerical moelling tools and can name several appliations. The students understand the impact of volcanic eruptions on climate and know both, presently as well as historically active volcanoes and their prominent eruptions.

The students have gained an overview about active volcanoes and recent eruptions and are able to summerize the main characteristics and scientific achievements about one volcano of their choice in a 10-15 minute talk. They are able to discuss and answer questions related to their subject.

Module grade calculation
The module is not graded.

Prerequisites
none

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101866 - Introduction to Volcanology, graded must not have been started.

Content

- Introduction, Overview
- Volcanoes and Plate Tectonics
- Magma and Volcanic Deposits
- Eruption types
- Volcanic Edifices
- Volcanic Hazard and Risk
- Volcano Monitoring
- Volcano Seismology
- Numerical Modelling of Volcanic Products
- Historic Eruptions
- Volcanoes and Climate

Workload

28 h: Attendance, active participation in lectures and practicals

14 h: Preparation and follow-up of lectures (at home)

18 h: Homework, assignments

30 h: Preparation of presentation

Learning type

4060251 Introduction to Volcanology (V1)
4060252 Exercises to Introduction to Volcanology (Ü1)

Literature

Literature will be provided by the lecturer.

M 3.26 Module: Measuring Methods in Physical Volcanology, graded [M-PHYS-101950]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
2	Irregular	German	4	2

Mandatory			
T-PHYS-103570	Measuring Methods in Physical Volcanology, Prerequisite	1 CR	Gottschämmer
T-PHYS-103671	Measuring Methods in Physical Volcanology, exam	1 CR	Gottschämmer

Competence Certificate

- Literature studies, active participation in lecture and discussion
- Oral exam, duration approximately 30 minutes

Competence Goal

Die Studierenden kennen physikalische Messverfahren, die verwendet werden, um aktive und potentiell aktive Vulkane zu überwachen. Sie können diese einordnen und können Messverfahren, die verwendet werden, um Ausbruchsmechanismen zu verstehen und den Aufbau aktiver und inaktiver Vulkane zu analysieren von jenen unterscheiden, die bevorzugt für die Überwachung aktiven Vulkane verwendet werden. Die Studierenden verstehen die physikalischen Prinzipien, die den Messungen zugrunde liegen, können die Physik, die benötigt wird, erläutern und vergleichen. Die Studierenden können nach Fachliteratur recherchieren und auch fachlich anspruchsvolle Literatur in den Grundzügen verstehen und wiedergeben.

Die Studierenden können das Wissen über die Messverfahren verknüpfen und auf eine unbekannte Fragestellung anwenden.

Prerequisites

Introduction to volcanology

Modeled Conditions

The following conditions have to be fulfilled:

1. The module M-PHYS-101871 - Measuring Methods in Physical Volcanology, not graded must not have been started.

Content

- Einführung in physikalische Messverfahren an Vulkanen
- Messung seismischer Signale
- Messung von Infraschall
- Messung der Temperatur
- Methode des Dopplerradar
- Deformationsmessungen
- Gasmessungen
- Elektrische und magnetische Methoden

Workload

- 15 h lecture including preparation and wrap-up
- 15 h homework (literature studies)
- 30 h preparation for exam

Literature

Will be announced during the lecture.

M 3.27 Module: Measuring Methods in Physical Volcanology, not graded [M-PHYS-101871]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Irregular	German	4	2

Mandatory			
T-PHYS-103570	Measuring Methods in Physical Volcanology, Prerequisite	1 CR	Gottschämmer

Competence Certificate
Literature studies, active participation in lecture and discussion

Competence Goal
Die Studierenden kennen physikalische Messverfahren, die verwendet werden, um aktive und potentiell aktive Vulkane zu überwachen. Sie können diese einordnen und können Messverfahren, die verwendet werden, um Ausbruchsmechanismen zu verstehen und den Aufbau aktiver und inaktiver Vulkane zu analysieren von jenen unterscheiden, die bevorzugt für die Überwachung aktiven Vulkane verwendet werden. Die Studierenden verstehen die physikalischen Prinzipien, die den Messungen zugrunde liegen, können die Physik, die benötigt wird, erläutern und vergleichen. Die Studierenden können nach Fachliteratur recherchieren und auch fachlich anspruchsvolle Literatur in den Grundzügen verstehen und wiedergeben.

Prerequisites
Introduction to volcanology

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101950 - Measuring Methods in Physical Volcanology, graded must not have been started.

Content

- Einführung in physikalische Messverfahren an Vulkanen
- Messung seismischer Signale
- Messung von Infraschall
- Messung der Temperatur
- Methode des Dopplerradar
- Deformationsmessungen
- Gasmessungen
- Elektrische und magnetische Methoden

Workload

- 15 h lecture including preparation and wrap-up
- 15 h homework (literature studies)

Literature
Will be announced during the lecture.

M 3.28 Module: Modern Physics Laboratory Course [M-PHYS-101355]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Duration	Language	Level	Version
6	Each term	1 term	German	4	1

Mandatory			
T-PHYS-102291	Modern Physics Laboratory Courses	6 CR	Naber

Module grade calculation
The lab course is not graded.

Prerequisites
Classical Physics Laboratory Courses I and II

M 3.29 Module: Modul Master Thesis [M-PHYS-101730]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Master Thesis

Credits	Recurrence	Language	Level	Version
30	Each term	German/English	4	2

Mandatory			
T-PHYS-103350	Master Thesis	30 CR	Bohlen

Competence Certificate
Successful completion of the master's thesis and successful defense during a public colloqium.

Competence Goal
The students are able to work independently on a scientific topic, guided by an experienced supervisor. They analyze problems, develop suitable solutions, interpret and assess results, and communicate those results and findings in writing in a clear and concise way in either German or English. Furthermore, by presenting and defending the work in a public colloquium the students constructively interact with fellow scientists as part of a scientific exchange.

Prerequisites
The modules 'Scientific Focusing Phase', 'Introduction to Scientific Practice', and 'Scientific Seminars' must be passed.

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101360 - Scientific Focusing Phase must have been passed.
2. The module M-PHYS-101361 - Introduction to Scientific Practice must have been passed.
3. The module M-PHYS-101357 - Scientific Seminars must have been passed.

Content

- Independent but supervised work on the topic of the master's thesis
- Public colloquium open to all members of the faculty (no more than six weeks after finalizing the master's thesis)

Annotation

The module “Master Thesis” is preceded by the module “Scientific Focusing Phase” and the module “Introduction to Scientific Practice”, which has a total duration of 6 months. Registration for the module “Scientific Focusing Phase” should be **no later than three months after the last course exam**. The third and fourth terms of the master’s program form a closely linked unit. At the time of the changeover from the second to the third term, the students should seek a topic for a master thesis. This topic will be set at the beginning of the “Scientific Focusing Phase”. The master thesis aims to show that the student is able to work on a subject independently and in a limited time according to scientific methods that correspond to the current state of research. This usually requires a thorough introduction to the scientific field of the master thesis and the learning of specific, scientific tools and methods. Since the duration of the master thesis is only six months, the modules “Scientific Focusing Phase” and “Introduction to Scientific Practice” in the third term are used by the student to familiarize himself/herself with the topic of the master thesis. Thus, at the beginning of the fourth term a “flying start” in the actual master thesis is possible. Altogether, exactly 12 months are available for work in the specific field of the master thesis.

Process

1. Before the beginning of the “Scientific Focusing Phase”, the student chooses a topic for a master thesis. For this he talks to the heads of the research areas at the Geophysical Institute and/or attends the seminars of the research areas.
2. Once the topic of the master thesis has been agreed on, students will register online for exams in the modules “Scientific Focusing Phase” and “Introduction to Scientific Practice”.
3. The student then visits the Examination Office of the Faculty of Physics. There the prerequisites for the Master’s thesis will be checked and he/she will receive a registration form for the topic of the master thesis.
4. The student passes the form to the supervisor/ reviewer of the Master’s thesis. In mutual agreement they fill in the fields ’Referent’ (supervisor/ reviewer), ’Korreferent’ (co-supervisor/ co-reviewer), ’Vorläufiges Thema der Arbeit’ (preliminary subject), and ’Beginn der Arbeit’ (start date). The principal reviewer signs the form and returns it to the Examination Office where the respective entry for the Master’s thesis will be created in the online system. The deadline for the thesis will then be available to the student through the online system. The supervisor contacts the webmaster (webmaster@gpi.kit.edu) to include the student in the list of master students.
5. The student can only return the topic of the master thesis once and only within the first month (Study and Examination Regulations 14 [6]). If he/she makes use of it, he/she informs the supervisor and the reviewers. The principal reviewer informs the Examination Office and resigns the student from the examination of the “Scientific Focusing Phase”. The student starts again at point 1.
6. Six months after the registration of the topic of the master thesis, the student performs the examination in the module “Scientific Focusing Phase” (lecture) and in the module “Introduction to Scientific Practice” (written report). The main reviewer records the grade in the electronic examination system.

Submission of master thesis

No later than twelve months after registration for the module “Scientific Focusing Phase” or the date of submission indicated on the registration form, the thesis must be submitted to the Examination Office of the Faculty of Physics. The title page must contain the English and German title.

Workload

Total workload: 900 h.

Literature

Topic-specific, literature provided by the supervisor of the master's thesis

M 3.30 Module: Module Wildcard Electives [M-PHYS-103142]

Organisation: University
Part of: Electives

Credits	Recurrence	Language	Level	Version
16	Each term	German	4	2

Election block: Platzhalter (at least 1 item as well as between 2 and 16 credits)			
T-PHYS-106249	Wildcard	2 CR	
T-PHYS-106253	Wildcard	2 CR	

Prerequisites
None

M 3.31 Module: Near Surface Geophysical Prospecting [M-PHYS-101946]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Irregular	German	4	1

Mandatory			
T-PHYS-103645	Near Surface Geophysical Prospecting, Prerequisite	1 CR	Gottschämmer

Competence Certificate
6 h: Vorlesung (Einführungsveranslatung) am GPI

7 h: In-Situ-Vorlesung im Gelände

17 h: Übungsblatt, Projektarbeit, Nachbereitung

M 3.32 Module: Near-surface seismic and GPR [M-PHYS-103855]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Each winter term	English	4	1

Mandatory			
T-PHYS-107793	Near-surface seismic and GPR	6 CR	Bohlen, Pan

Competence Certificate
Final pass based on successful participation of the exercises.

Competence Goal
The students know the fundamentals about wave propagation phenomena near the Earth's surface and near-surface investigations for both seismic and electromagnetic waves. They comprehend the wave composition of shallow seismic wavefields and the dispersion and multimodal characteristics of surface waves. The students understand the multichannel analysis of surface waves method and the properties of dispersion curves, how to image surface-wave dispersion curves from active-source and passive-source seismic data, and how to estimate near-surface S-wave velocity and Q-factor structures by solving inverse problems. They know and can describe the elastic-wave equations, dispersion equations, the Radon transform, least-square optimization methods, seismic interferometry, and the spatial autocorrelation method. Finally, students are able to process shallow-seismic field data and use analysis methods to solve simple near-surface geophysical and geotechnical problems.

Module grade calculation
The coursework is not graded.

Prerequisites
None

Content

- Designing shallow-seismic acquisition systems
- Imaging, forward-calculation and inversion of surface-wave dispersion curves
- Multimodal characteristics of surface waves
- Inversion of surface-wave attenuation coefficients for quality factors
- Passive-source shallow seismic methods
- Marine surface-wave method
- Full-waveform inversion of shallow seismic data
- GPR method

Recommendation
No explicit requirements. However, basic knowledge of seismic methods, wave propagation phenomena, and signal processing is essential.

Literature
Final pass based on successful participation of the exercises.

M 3.33 Module: Physics of the Lithosphere, graded [M-PHYS-101960]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
3	Irregular	German	4	1

Mandatory			
T-PHYS-103574	Physics of the Lithosphere, Studienleistung	2 CR	Gottschämmer
T-PHYS-103678	Physics of the Lithosphere, exam	1 CR	Gottschämmer

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101875 - Physics of the Lithosphere, not graded must not have been started.

M 3.34 Module: Physics of the Lithosphere, not graded [M-PHYS-101875]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
2	Irregular	German	4	1

Mandatory			
T-PHYS-103574	Physics of the Lithosphere, Studienleistung	2 CR	Gottschämmer

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-101960 - Physics of the Lithosphere, graded must not have been started.

M 3.35 Module: Recent Geodynamics (GEOD-MPGF-1) [M-BGU-101030]

Responsible: Dr. Malte Westerhaus
Organisation: KIT Department of Civil Engineering, Geo- and Environmental Sciences
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Each winter term	German/English	4	1

Mandatory			
T-BGU-101772	Recent Geodynamics, Prerequisite	1 CR	Westerhaus
T-BGU-101771	Recent Geodynamics	3 CR	Westerhaus

M 3.36 Module: Scientific Focusing Phase (GEOP M SP) [M-PHYS-101360]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Scientific Focusing Phase

Credits	Recurrence	Duration	Language	Level	Version
10	Each term	1 term	English	4	3

Election block: Vorleistung SpezPhas (1 item)			
T-PHYS-107675	Seminar on Recent Topics of Applied Geophysics	10 CR	Bohlen
T-PHYS-107676	Seminar on Recent Topics of General Geophysics	10 CR	Gottschämmer, Rietbrock
T-PHYS-110593	Seminar Seismological Analysis	10 CR	Ritter

Competence Certificate
Examination of other type, not graded.

The examination of other type can be repeated at any time. However, only one reexamination is permitted.

Oral presentation, scientific discussion of the task at hand and the outcome of the student's work, and critical assessment in the relevant workgroup seminar. Pass granted upon successful completion of the presentation/discussion.

Competence Goal
The students fully understand the task of their master thesis at hand and its scientific background. They know the principle approach how to address scientific questions and have gained detailed knowledge regarding their specific subject, supervised by a member of the relevant workgroup. Through active participation in scientific discussions and presenting their own results, students are able to present and to exchange scientific opinions and critically assess results. They understand the importance of feedback and know how to incorporate constructive feedback into their work and working procedures.

Module grade calculation
The module is not graded.

Content
The students work independently but supervised on a specific scientific task related to their upcoming master thesis.

- Independent but supervised work on a specific scientific task related to the upcoming master thesis
- Active participation in the relevant workgroup seminar

Workload
10 ECTS in total, corresponding to 300 working hours.

Learning type

- 4060234 Seminar on Applied Geophysics (S2)
- 4060274 Current Topics in Seismology and Hazard (S2)
- 4060244 Seminar Seismological Analysis (S2)

Literature
Task-specific, literature provided by the supervisor

3.37 Module: Scientific Seminars (GEOP M WS) [M-PHYS-101357]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: Introduction to Scientific Practice

Credits	Recurrence	Duration	Language	Level	Version
4	Each term	1 term	English	4	2

Mandatory			
T-PHYS-102335	Scientific Seminars	4 CR	

Competence Certificate
To be successful the student has to properly document the attendance at 12 seminars.

Competence Goal
The students comprehend geoscientific and physical problems, concepts and methods in a broad context beyond the core curriculum. They are able to make reasonable links to existing knowledge when listening to seminar presentations on subjects outside their field of specialization. They are able to summarize the key messages of seminar presentations. The students are able to join a critical scientific discourse. They ask well thought and precise questions in the aim to clarify misapprehensions and to deepen their understanding of neighboring scientfic disciplines.

Module grade calculation
The module is not graded.

Content
The students attend at least 12 seminar presentations at the geophysical institute, the faculty of physics, and institutes of neighboring disciplines in earth sciences, at their choice. They gain an overview of major current research topics in the fields of these seminars. This way they broaden their understanding beyond their area of specialization. The students listen carefully to the presentations and make notes stating significant points of the presented subject as well as questions to be asked. They critically assess the consistency of the presentation within itself and with their existing knowledge. In the discussion of the presentation they ask appropriate questions to clarify apparent inconsistency or fill gaps of missing information. After the seminar they discuss the contents and new information with fellow students and prepare a short (5 to 10 lines) summary of the respective presentation.

Annotation
Each student attends at least 12 seminar presentations at the geophysical institute, the faculty of physics, and institutes of neighbouring disciplines in earth sciences (additional seminars may be accepted if the student applies for this in advance). Lists of current seminar programs are provided at http://www.gpi.kit.edu/english/Seminar.php

At each seminar they make notes on a form sheet (seminar report) which is provided for download (http://www.gpi.kit.edu/downloads/SeminarReport.pdf). The notes are not necessarily complete in terms of lecture notes. They can be rather a collection of dispersed notes, keywords, and sketches. However, they shall reflect the students judgement regarding major issues of the presentation, consistency of content, and the way they used questions to clarify open issues in the discussion of the seminar. They complement these notes by a short (5 to 10 lines) summary of the seminar which shall be written in full, proper sentences in a comprehensible and pointed way. If the presentation was not comprehensible this shall be described appropriately in the summary.

After having attended 12 seminars the students fill in a list (form is provided for download: http://www.gpi.kit.edu/downloads/ListOfSeminars.pdf) of seminars and submit this together with the 12 corresponding report sheets to the examiner.

The examinar checks the reports and invites the student for a short interview. This interview shall give evidence, that the student in fact attended all the listed seminars. After a successful discussion of the report sheets, the examinar keeps the signed list of seminars for documentation and returns the reports to the student.

Workload
Total workload: 120 h, further details will be given individually.

Learning type

- 4060294 Geophysikalisches Institutsseminar
- 6020730 Geodätisches Kolloquium
- 6339044 Geologisches Fachgespräch für Diplomanden, Doktoranden und Gäste
- 4039995 Physikalisches Kolloquium

Literature
Abstracts published in the seminar programs.

M 3.38 Module: Seismic Data Processing with final report (graded) [M-PHYS-104186]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Irregular	English	4	1

Mandatory			
T-PHYS-108656	Seismic Data Processing, final report (graded)	4 CR	Bohlen, Hertweck
T-PHYS-108686	Seismic Data Processing, coursework	2 CR	Bohlen, Hertweck

Competence Certificate
Students have to participate the lecture/exercise on a regular basis and give a final presentation about their processing results (2 ECTS points). Students who would like to get the full 6 ECTS points also need to prepare and hand in a seismic data processing report. The report will determine the final grade (if applicable).

Competence Goal
The students have hands-on experience applying typical seismic processing and imaging techniques to reflection seismic field data. In this way, they understand the reflection seismic method and have practical skills in data analysis and problem solving which are beneficial in their professional life later on, not only in exploration. Students can set up a basic processing and imaging flow, understand the individual processing steps and their purpose, and describe the influence of important parameters on processing results. They are able to identify data shortcomings and imaging challenges and develop basic solutions, analyze the success of individual processing/imaging steps, and critically assess the overall quality of their work. Finally, students are able to present their processing results in oral and written form.

Module grade calculation
The report will determine the final grade.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104188 - Seismic Data Processing with final report (ungraded) must not have been started.
2. The module M-PHYS-104189 - Seismic Data Processing without final report (ungraded) must not have been started.

Content

- Field data loading, quality control, trace edits and geometry setup
- Spectral analysis, filter application, geometrical spreading correction
- Deconvolution, zero-phasing
- Denoising using various approaches
- Multiple identification and removal (SRME, Radon)
- CMP sort, velocity analysis, NMO correction, mute and stack
- Time migration (prestack and poststack)
- Post-migration processing
- Basic interpretation (in cooperation with KIT-AGW)
- Optional: depth velocity model building and depth migration

Recommendation
No explicit requirements. However, basic knowledge of the reflection seismic method and general computer skills are essential. This course does not require any programming skills.

Annotation
A commercial data processing software is used during this course.

Learning type

4060321 Th.Bohlen, Th. Hertweck (V1)

4060322 Th.Bohlen, Th. Hertweck (Ü2)

Literature

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Robert Sheriff and Lloyd Geldart, "Exploration Seismology", 1995, Cambridge University Press.

M 3.39 Module: Seismic Data Processing with final report (ungraded) [M-PHYS-104188]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: Electives

Credits	Recurrence	Language	Level	Version
6	Irregular	English	4	1

Mandatory			
T-PHYS-108657	Seismic Data Processing, final report (ungraded)	4 CR	Bohlen, Hertweck
T-PHYS-108686	Seismic Data Processing, coursework	2 CR	Bohlen, Hertweck

Competence Certificate
Students have to participate the lecture/exercise on a regular basis and give a final presentation about their processing results (2 ECTS points). Students who would like to get the full 6 ECTS points also need to prepare and hand in a seismic data processing report. The report will determine the final grade (if applicable).

Competence Goal
The students have hands-on experience applying typical seismic processing and imaging techniques to reflection seismic field data. In this way, they understand the reflection seismic method and have practical skills in data analysis and problem solving which are beneficial in their professional life later on, not only in exploration. Students can set up a basic processing and imaging flow, understand the individual processing steps and their purpose, and describe the influence of important parameters on processing results. They are able to identify data shortcomings and imaging challenges and develop basic solutions, analyze the success of individual processing/imaging steps, and critically assess the overall quality of their work. Finally, students are able to present their processing results in oral and written form.

Module grade calculation
The coursework is not graded.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104186 - Seismic Data Processing with final report (graded) must not have been started.
2. The module M-PHYS-104189 - Seismic Data Processing without final report (ungraded) must not have been started.

Content

- Field data loading, quality control, trace edits and geometry setup
- Spectral analysis, filter application, geometrical spreading correction
- Deconvolution, zero-phasing
- Denoising using various approaches
- Multiple identification and removal (SRME, Radon)
- CMP sort, velocity analysis, NMO correction, mute and stack
- Time migration (prestack and poststack)
- Post-migration processing
- Basic interpretation (in cooperation with KIT-AGW)
- Optional: depth velocity model building and depth migration

Recommendation
No explicit requirements. However, basic knowledge of the reflection seismic method and general computer skills are essential. This course does not require any programming skills.

Annotation
A commercial data processing software is used during this course.

Learning type
4060321 Th.Bohlen, Th. Hertweck (V1)

4060322 Th.Bohlen, Th. Hertweck (Ü2)

Literature

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Robert Sheriff and Lloyd Geldart, "Exploration Seismology", 1995, Cambridge University Press.

M 3.40 Module: Seismic Data Processing without final report (ungraded) [M-PHYS-104189]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: Electives

Credits	Recurrence	Language	Level	Version
2	Irregular	English	4	1

Mandatory			
T-PHYS-108686	Seismic Data Processing, coursework	2 CR	Bohlen, Hertweck

Competence Certificate
Students have to participate the lecture/exercise on a regular basis and give a final presentation about their processing results (2 ECTS points). Students who would like to get the full 6 ECTS points also need to prepare and hand in a seismic data processing report. The report will determine the final grade (if applicable).

Competence Goal
The students have hands-on experience applying typical seismic processing and imaging techniques to reflection seismic field data. In this way, they understand the reflection seismic method and have practical skills in data analysis and problem solving which are beneficial in their professional life later on, not only in exploration. Students can set up a basic processing and imaging flow, understand the individual processing steps and their purpose, and describe the influence of important parameters on processing results. They are able to identify data shortcomings and imaging challenges and develop basic solutions, analyze the success of individual processing/imaging steps, and critically assess the overall quality of their work. Finally, students are able to present their processing results in oral and written form.

Module grade calculation
The coursework is not graded.

Prerequisites
None

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-PHYS-104186 - Seismic Data Processing with final report (graded) must not have been started.
2. The module M-PHYS-104188 - Seismic Data Processing with final report (ungraded) must not have been started.

Content

- Field data loading, quality control, trace edits and geometry setup
- Spectral analysis, filter application, geometrical spreading correction
- Deconvolution, zero-phasing
- Denoising using various approaches
- Multiple identification and removal (SRME, Radon)
- CMP sort, velocity analysis, NMO correction, mute and stack
- Time migration (prestack and poststack)
- Post-migration processing
- Basic interpretation (in cooperation with KIT-AGW)
- Optional: depth velocity model building and depth migration

Recommendation
No explicit requirements. However, basic knowledge of the reflection seismic method and general computer skills are essential. This course does not require any programming skills.

Annotation
A commercial data processing software is used during this course.

Learning type

4060321 Th.Bohlen, Th. Hertweck (V1)

4060322 Th.Bohlen, Th. Hertweck (Ü2)

Literature

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Robert Sheriff and Lloyd Geldart, "Exploration Seismology", 1995, Cambridge University Press.

M 3.41 Module: Seismometry, Signal Processing and Seismogram Analysis (GEOP M MSS) [M-PHYS-101358]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: Geophysics

Credits	Recurrence	Duration	Language	Level	Version
22	Each winter term	1 term	English	4	3

Mandatory			
T-PHYS-102325	Physics of Seismic Instruments, Prerequisite	0 CR	Forbriger
T-PHYS-109267	Seismology, Prerequisite	0 CR	Rietbrock
T-PHYS-109266	Seismics, Prerequisite	0 CR	Bohlen
T-PHYS-106217	Seismometry, Signal Processing and Seismogram Analysis, Exam	22 CR	Bohlen

Competence Certificate
General

To pass the module, the oral exam must be passed. As prerequisites the examinations of other type (of all three courses) must be passed.

The examination prerequisites are successful participation in 'Exercises of Physics of Seismic Instruments', 'Exercises of Seismology' and 'Exercises of Seismics'.

The oral exam with a duration of approximately 60 minutes covers the complete content of all exercises and lectures of the module comprehensively. The examinations of other type check the contents of the corresponding exercises.

In general, the examinations of other type can be repeated within 8 weeks, but at the latest within the period of one year. An oral reexamination usually takes place at the beginning of the next semester at the latest. A missed oral reexamination may be repeated once.

Physics of Seismic Instruments

In order to pass the course Physics of Seismic Instruments, a student must successfully participate the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Seismology

In order to pass the course Seismology, a student must successfully participate the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Seismics

In order to pass the course Seismics, a student must successfully participate the corresponding exercise classes. Successful participation is based on exceeding a certain percentage of the combined total number of points awarded, as applicable, for exercise sheets, other homework (such as, for instance, reports) and written tests held as part of the exercises. The percentage threshold is communicated to students at the beginning of the course and documented in Ilias.

Competence Goal

Physics of Seismic Instruments

The students understand the causes and consequences of different physical excitation mechanisms for inertial seismometers. They can explain essential considerations for installation and shielding. The students understand the concept of frequency response and are able to express a transfer function in terms of poles and zeroes. They can apply these concepts to sensors with electrodynamic transducers. The students can explain the significance of linearity. They are able to quantitatively infer the physical input signal from the recording of a seismic instrument. The stundents are able to use the concepts of bandwidth and dynamic range when expressing properties of signals and instruments. The students know means to express noise levels and to estimate instrumental self-noise. They can explain measures to increase the sensitivity and can explain the essential principles of modern force-balance feedback seismometers.

Seismology

The students understand the fundamental concepts of seismology and the earthquake rupture process. They have a knowledge of seismogram interpretation, fundamentals of seismic wave propagation and the representations of the earthquake source. Students are able to apply their knowledge to observed data to gain an insight into the Earth structure and the earthquake source.

Seismics

The students know the fundamental concepts of seismic acquisition, processing and imaging in reflection seismics. They can correctly name equipment, tools and processes and effectively communicate with specialists in the field of seismics. Students understand the various steps involved in seismic processing/imaging, their underlying theory and how they affect the data. They are able to apply the concepts and equations to simple exemplary seismic data.

Module grade calculation

The grade of the module results from grade of the oral exam.

Content

Physics of Seismic Instruments

- The mechanical sensor and the driven harmonic oscillator
- Various driving forces and wanted and unwanted sensitivity
- Installation and shielding
- The seismometer with electrodynamic transducer, effective gain, and damping due to passive electrodynamic feedback
- The frequency response, transfer function, poles and zeroes, non-linearity
- Seismic signals, bandwidth, dynamic range, and noise floor
- The force-balance feedback seismometer, displacement transducer, phase sensitive rectifier, controller, and the role of open-loop gain
- Effective transfer function of the velocity broad-band seismometer

Seismology

- History of seismology
- Elasticity and seismic waves
- Body waves and surface waves
- Seismogram interpretation
- Earthquake location
- Determination of Earth structure
- Seismic sources
- Seismic moment tensor
- Earthquake kinematics and dynamics
- Seismotectonics

Seismics

- Overview of seismic methods and wave propagation basics
- Essential signal processing concepts and tools
- Seismic acquisition, sources and receivers, marine and land
- Geometries and traveltimes, NMO and DMO
- Processing steps: from data loading to denoise and demultiple
- Velocity analysis, NMO correction, stacking, SNR
- Imaging: basic concepts, time and depth migration, migration methods
- Seismic resolution
- Optional: advanced acquisition, processing and imaging technologies

Recommendation
Physics of Seismic Instruments

A sound knowledge of the theory of ordinary differential equations and integral transformations (Fourier transformation) is expected. Basic skills in pratical signal processing using elementary computer programming techniques are needed in the exercises. A basic understanding of seismic waves in the Earth is helpful.

Seismology

A sound knowledge of the fundamentals in Geophysics. Basic skills in programming and Python to solve exercises.

Seismics

Experience with Matlab, the Linux commandline, and shell scripts is beneficial. Knowledge of fundamental signal processing theory is essential.

Workload
22 ECTS in total, corresponding to 660 working hours. For the specific courses:

- Physics of Seismic Instruments: 180 h
- Seismology: 240 h
- Seismics: 240 h

Learning type

- Physics of Seismic Instruments (V2 Ü1, 3 SWS, 6 ECTS, prerequisite for oral examination)
- Seismology (V2 Ü2, 4 SWS, 8 ECTS, prerequisite for oral examination)
- Seismics (V2 Ü2, 4 SWS, 8 ECTS , prerequisite for oral examination)

Literature
Physics of Seismic Instruments

- Bormann, P., (ed.), 2012. New Manual of Seismological Observatory Practice. 2nd edition. GeoForschungsZentrum Potsdam. DOI: 10.2312/GFZ.NMSOP-2. http://dx.doi.org/10.2312/GFZ.NMSOP-2. Chapters 4 and 5 in particular.

Further recommendations will be given during the course.

Seismology

- Peter M. Shearer, "Introduction to Seismology", Cambridge Uniersity Press.
- Thorne Lay and Terry C. Wallace, "Modern Global Seismology", Academic Press.
- Seth Stein and Michael Wysession, "An Introduction to Seismology, Earthquakes, and Earth Structure", Blackwell Publishing.

Seismics

- Öz Yilmaz, "Seismic Data Analysis", 2001, Society of Exploration Geophysicists.
- Luc Ikelle and Lasse Amundsen, "Introduction to Petroleum Seismology", 2005, Society of Exploration Geophysicists.
- Jon Claerbout, "Fundamentals of geophysical data processing", 1976, McGraw-Hill.
- Etienne Robein, "Seismic Imaging: A Review of the Techniques, their Principles, Merits and Limitations", 2010, European Association of Geoscientists and Engineers.

M 3.42 Module: Seminar on recent topics of risk science [M-PHYS-103803]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Each winter term	English	4	2

Mandatory			
T-PHYS-107673	Seminar on Recent Topics of Risk Science	4 CR	Gottschämmer

Competence Certificate
Preparation and presentation of several presentation(s) based on a scientific publication, critical discussion of the scientific results.

Competence Goal
The students understand scientific literature regarding current topics of natural hazards and risk. They can summarize a selected topic, describe and explain the main idea to their fellow students in an oral presentation (30-40 minutes). They know how to structure and present a scientific talk. They are able to understand the topics presented by their fellow students, discuss and analyze the content critically. They are able to compare those research results and evaluate the content critically.

Module grade calculation
The module is not graded.

Prerequisites
None

Content
The students will read and discuss current literature about current topics of natural hazards and risk.

Workload
Presence at seminar, dicussions, presentation of homework: 30 h

Preparation, reading (homework): 90 h

Learning type
4060254 Seminar über aktuelle Fragen aus der Risikoforschung (S2)

Literature
Will be announced during the seminar.

M 3.43 Module: Structural Geology and Tectonics [M-BGU-101996]

Responsible: Prof. Dr. Agnes Kontny
Organisation: KIT Department of Civil Engineering, Geo- and Environmental Sciences
Part of: Electives

Credits	Recurrence	Language	Level	Version
4	Each winter term	German	4	1

Mandatory			
T-BGU-103712	Structural Geology and Tectonics	4 CR	Kontny

Prerequisites
None

M 3.44 Module: The Black Forest Observatory at Schiltach [M-PHYS-101870]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: Electives

Credits	Recurrence	Language	Level	Version
1	Irregular	German	4	1

Mandatory			
T-PHYS-103569	The Black Forest Observatory at Schiltach, Prerequisite	1 CR	Gottschämmer

M 3.45 Module: Theory and Inversion of Seismic Waves (GEOP M TIW) [M-PHYS-101359]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: Geophysics

Credits	Recurrence	Duration	Language	Level	Version
18	Each summer term	1 term	English	4	3

Mandatory			
T-PHYS-102330	Theory of Seismic Waves, Prerequisite	0 CR	Bohlen
T-PHYS-102332	Inversion and Tomography, Prerequisite	0 CR	Ritter
T-PHYS-108636	Seismic Modelling, Prerequisite	0 CR	Bohlen
T-PHYS-106218	Theory and Inversion of Seismic Waves, Exam	18 CR	Bohlen

Competence Certificate

General

To pass the module, the oral exam must be passed. As prerequisites the examinations of other type (of all three courses) must be passed.

The examination prerequisites are successful participation in 'Exercises of Theory of Seismic Wave', 'Exercises of Seismic Modelling' and 'Exercises of Inversion and Tomography'.

The oral exam with a duration of approximately 60 minutes covers the complete content of all exercises and lectures of the module comprehensively. The examinations of other type check the contents of the corresponding exercises.

In general, the examinations of other type can be repeated within 8 weeks, but at the latest within the period of one year. An oral reexamination usually takes place at the beginning of the next semester at the latest. A missed oral reexamination may be repeated once.

Theory of Seismic Waves

Final pass based on successful participation of the exercises. Each exercise deals with a specific topic (e.g., stress and strain tensors, Zoeppritz equations, or rays) and is based on solving a given theoretical problem by means of calculus. In some cases equations and solutions need to be visualized using Matlab (or equivalent tools).

Seismic Modelling

Final pass based on successful participation of the exercises. Each exercise deals with a specific topic (e.g., 1D finite-difference implementation) and is based on hands-on work, usually involving the use of computers.

Inversion and Tomography

Students write reports on their exercise work. These reports are rated. The necessary number of points is explained at the beginning of the individual exercises.

Competence Goal

Theory of Seismic Waves

The students know the fundamental laws and equations of linear elasticity and wave propagation. They understand wave propagation phenomena such as source effects, reflection and transmission or the effects of anisotropy, absorption, dispersion and scattering and can describe them in mathematical terms. They are able to apply the concepts and equations to theoretical problems and relate the theory to phenomena observed in field data.

Seismic Modelling

The students know the fundamental concepts of seismic wavefield simulations, including the mathematical descriptions and their basic numeric implementations. They understand the complexity of wave propagation and the advantages and disadvantages of the individual methods. They are able to apply the methods using synthetic Earth models to calculate amplitudes and traveltimes of propagating elastic and/or acoustic waves.

Inversion and Tomography

The students understand how to invert data to achieve a model of physical parameters. The students realize that seismic waves can be treated in different waves: full waveform, finite-frequency approximations (banana-doughnut theory) and rays. From this they understand how seismic images can be constructed and interpreted. Students are able to evaluate inversion models based on error bonds, resolution matrices and reconstruction tests. They know the complete chain of tomography: data pre-processing, parameterization, inversion, model assessment and interpretation. The students are used to read scientific papers on inversion and tomography and to discuss questions on these papers. Finally the students are able to understand basic inverse problems and read more advanced texts. Practically, the students understand how to code simple problems with Matlab or possibly Python. The students know how to analyze inverse problems using singular value decomposition and other methods.

Module grade calculation

The grade of the module results from grade of the oral exam.

Content

Theory of Seismic Waves

- Theory of elasticity, stress and strain, elastic tensor, fundamental laws and equations
- Anisotropic elastic wave equation and various simplifications
- Mathematical description of sources, near-field and far-field terms
- Boundary conditions
- Reflection and transmission of plane waves at plane interfaces, Zoeppritz equations
- Surface waves, dispersion relation, phase and group velocity
- Introduction to ray theory, eikonal and transport equations and their solutions
- Absorption and dispersion
- Wave propagation in anisotropic media
- Scattering

Seismic Modelling

- Factors influencing traveltimes and amplitudes of seismic wavefields
- Analytical solutions
- Fast traveltime calculation using the eikonal equation
- Raytracing
- Reflectivity method for acoustic 1D media
- Time-domain finite-difference solutions of the acoustic/elastic wave equations
- Fourier methods
- Introduction to the finite-element method

Inversion and Tomography

- Fundamentals of tomography
- Application of seismic tomography
- Regional to global seismic tomography
- Analysis of tomography problems
- Fundamentals in seismic inversion
- Application of linear and non-linear inversion

Recommendation

Theory of Seismic Waves

Knowledge of differential and vector calculus is essential. Familiarity with Matlab (alternatively Python or Mathematica) is beneficial for certain exercises.

Seismic Modelling

Knowledge of differential and vector calculus is essential. Familiarity with Matlab (alternatively Python or Mathematica) is beneficial for certain exercises.

Inversion and Tomography

Knowledge on fundamentals of seismology and understanding of mathematics, especially matrix calculus. Fundamental skills in Linux, Matlab and computing in general.

Workload

18 ECTS in total, corresponding to 540 working hours. For the specific courses:

- Theory of Seismic Waves: 180 h
- Seismic Modelling: 120 h
- Inversion and Tomography: 240 h

Learning type

- Theory of Seismic Waves (V2 Ü1, 3 SWS, 6 ECTS, prerequisite for oral examination)
- Seismic Modelling (V1 Ü1, 2 SWS, 4 ECTS, prerequisite for oral examination)
- Inversion und Tomographie (V2 Ü2, 4 SWS, 8 ECTS , prerequisite for oral examination)

Literature

Theory of Seismic Waves

- Aki and Richards, "Quantitative Seismology", 2003, University Science Books.
- Ben-Menahem and Singh, "Seismic waves and sources", 1981, Springer.
- Dahlen and Tromp, "Theoretical Global Seismology", 1998, Princeton University Press.
- Frank Hadsell, "Tensors of Geophysics for Mavericks and Mongrels", 1995, Society of Exploration Geophysicists.

Seismic Modelling

- Carcione, Herman and Kroode, "Seismic modeling", 2000, Geophysics 67(4).

Inversion and Tomography

- Nolet, G., 2008. A breviary of seismic tomography. Cambridge University Press.
- Aster, R.C., Brochers, B. & Thurber, C.H., 2012. Parameter estimation and inverse problems. Elsevier (2nd ed.).
- Menke, W.A., 2012. Geophysical data analysis: discrete inverse theory. Academic Press (3rd ed.).

4 Courses

T 4.1 Course: 3D reflection seismics [T-PHYS-107806]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-103856 - 3D reflection seismics

Type	Credits	Recurrence	Version
Completed coursework	1	Irregular	1

T 4.2 Course: Black Forest Observatory Course [T-PHYS-106261]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: M-PHYS-103145 - Black Forest Observatory Course

Type	Credits	Recurrence	Version
Completed coursework	1	Each winter term	1

Events					
WS 19/20	4060914	Observatory course	2 SWS	Practical course (P)	Forbriger

T 4.3 Course: Classical Physics Laboratory Courses II [T-PHYS-102290]

Responsible: Prof. Dr. Günter Quast
Dr. Hans Jürgen Simonis

Organisation: KIT Department of Physics

Part of: M-PHYS-101354 - Classical Physics Laboratory Course II

Type	Credits	Recurrence	Version
Completed coursework	6	Each summer term	1

Events					
SS 2019	4011213	Praktikum Klassische Physik II (Kurs 1)	6 SWS	Practical course (P)	Quast, Simonis
SS 2019	4011223	Praktikum Klassische Physik II (Kurs 2)	6 SWS	Practical course (P)	Quast, Simonis

Prerequisites
none

T 4.4 Course: Full-waveform inversion [T-PHYS-109272]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104522 - Full-waveform Inversion, not graded

Type	Credits	Recurrence	Version
Completed coursework	6	Each winter term	1

Events					
WS 19/20	4060181	Full-waveform inversion	1 SWS	Lecture (V)	Bohlen, Pan
WS 19/20	4060182	Exercises on Full-waveform inversion	1 SWS	Practice (Ü)	Bohlen, Pan

4.5 Course: Full-waveform inversion (graded) [T-PHYS-110614]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-105235 - Full-waveform inversion, graded

Type	Credits	Recurrence	Version
Examination of another type	6	Each winter term	1

Events					
WS 19/20	4060181	Full-waveform inversion	1 SWS	Lecture (V)	Bohlen, Pan
WS 19/20	4060182	Exercises on Full-waveform inversion	1 SWS	Practice (Ü)	Bohlen, Pan

T 4.6 Course: Geodynamic Modelling I [T-PHYS-107998]

Responsible: Dr. Oliver Heidbach
Organisation: KIT Department of Physics
Part of: M-PHYS-103914 - Geodynamic Modelling I

Type	Credits	Recurrence	Version
Completed coursework	2	Each winter term	1

T 4.7 Course: Geodynamic Modelling II [T-PHYS-107999]

Responsible: Dr. Oliver Heidbach
Organisation: KIT Department of Physics
Part of: M-PHYS-103915 - Geodynamic Modelling II

Type	Credits	Recurrence	Version
Completed coursework	2	Each winter term	1

T 4.8 Course: Geological Hazards and Risk [T-PHYS-103525]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101833 - Geological Hazards and Risk

Type	Credits	Recurrence	Version
Examination of another type	8	Each winter term	2

Events					
WS 19/20	4060121	Geological Hazards and Risk	2 SWS	Lecture (V)	Gottschämmer, Daniell
WS 19/20	4060122	Exercises on Geological Hazards and Risk	2 SWS	Practice (Ü)	Gottschämmer, Daniell

T 4.9 Course: Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, exam [T-PHYS-103673]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101952 - Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, graded

Type	Credits	Version
Examination of another type	1	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course **T-PHYS-103571 - Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, Studienleistung** must have been passed.

T 4.10 Course: Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, Studienleistung [T-PHYS-103571]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101872 - Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, not graded
M-PHYS-101952 - Geophysical Deep Sounding at Volcanoes and the Example of the Vogelsberg, graded

Type	Credits	Version
Completed coursework	3	1

T 4.11 Course: Geophysical Investigation of Volcanic Fields, exam [T-PHYS-103672]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-101951 - Geophysical Investigation of Volcanic Fields, graded

Type	Credits	Version
Examination of another type	1	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103573 - Geophysical Investigation of Volcanic Fields, Prerequisite must have been passed.

T 4.12 Course: Geophysical Investigation of Volcanic Fields, Prerequisite [T-PHYS-103573]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-101874 - Geophysical Investigation of Volcanic Fields, not graded
M-PHYS-101951 - Geophysical Investigation of Volcanic Fields, graded

Type	Credits	Version
Completed coursework	3	1

T 4.13 Course: Geophysical Monitoring of Tunnel Constructions, Prerequisite [T-PHYS-106248]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-103141 - Geophysical Monitoring of Tunnel Constructions

Type	Credits	Version
Completed coursework	1	1

T 4.14 Course: Hazard and Risk Assessment of Mediterranean Volcanoes, exam [T-PHYS-103674]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101873 - Hazard and Risk Assessment of Mediterranean Volcanoes, graded

Type	Credits	Version
Examination of another type	2	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103572 - Hazard and Risk Assessment of Mediterranean Volcanoes, Prerequisite must have been passed.

4.15 Course: Hazard and Risk Assessment of Mediterranean Volcanoes, Prerequisite [T-PHYS-103572]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101873 - Hazard and Risk Assessment of Mediterranean Volcanoes, graded
M-PHYS-101953 - Hazard and Risk Assessment of Mediterranean Volcanoes, not graded

Type	Credits	Version
Completed coursework	4	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103553 - Introduction to Volcanology, Prerequisite must have been passed.

T 4.16 Course: Historical Seismology for Hazard Evaluation, Prerequisite [T-PHYS-103679]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101961 - Historical Seismology for Hazard Evaluation

Type	Credits	Recurrence	Version
Completed coursework	1	Irregular	1

T 4.17 Course: Induced Seismicity, exam [T-PHYS-103677]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-101959 - Induced Seismicity, graded

Type	Credits	Version
Examination of another type	2	1

Competence Certificate
The procedure will be announced in the lecture.

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103575 - Induced Seismicity, Studienleistung must have been passed.

T 4.18 Course: Induced Seismicity, Studienleistung [T-PHYS-103575]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-101878 - Induced Seismicity, not graded
M-PHYS-101959 - Induced Seismicity, graded

Type	Credits	Recurrence	Version
Completed coursework	3	Irregular	1

T 4.19 Course: In-Situ: Seismic Hazard in the Apennines [T-PHYS-108690]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-104195 - In-Situ: Seismic Hazard in the Apennines

Type	Credits	Version
Examination of another type	6	1

T 4.20 Course: In-Situ: Summer School Bandung: Seismology/Geohazards [T-PHYS-108691]

Responsible: Dr. Ellen Gottschämmer
Prof. Dr. Andreas Rietbrock

Organisation: KIT Department of Physics

Part of: M-PHYS-104196 - In-Situ: Summer School Bandung: Seismology/Geohazards

Type	Credits	Version
Examination of another type	6	1

Events					
SS 2019	4060351	In-Situ: Summer School Bandung: Seismology	2 SWS		Rietbrock, Gottschämmer
SS 2019	4060352	In-Situ: Summer School Bandung: Seismology	4 SWS	Practice (Ü)	Rietbrock, Gottschämmer

Prerequisites
none

T 4.21 Course: Introduction to Research in a Scientific Sub-Field Including a Seminar Paper [T-PHYS-103355]

Organisation: KIT Department of Physics
Part of: M-PHYS-101361 - Introduction to Scientific Practice

Type	Credits	Version
Completed coursework	16	1

T 4.22 Course: Introduction to Volcanology, Exam [T-PHYS-103644]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101866 - Introduction to Volcanology, graded

Type	Credits	Version
Examination of another type	1	1

Events					
SS 2019	4060251	Introduction to Volcanology	1 SWS	Lecture (V)	Gottschämmer, Rietbrock
SS 2019	4060252	Exercises to Introduction to Volcanology	1 SWS	Practice (Ü)	Gottschämmer, Rietbrock

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103553 - Introduction to Volcanology, Prerequisite must have been passed.

T 4.23 Course: Introduction to Volcanology, Prerequisite [T-PHYS-103553]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101866 - Introduction to Volcanology, graded
M-PHYS-101944 - Introduction to Volcanology, not graded

Type	Credits	Version
Completed coursework	3	1

Events					
SS 2019	4060251	Introduction to Volcanology	1 SWS	Lecture (V)	Gottschämmer, Rietbrock
SS 2019	4060252	Exercises to Introduction to Volcanology	1 SWS	Practice (Ü)	Gottschämmer, Rietbrock

T 4.24 Course: Inversion and Tomography, Prerequisite [T-PHYS-102332]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-101359 - Theory and Inversion of Seismic Waves

Type	Credits	Version
Completed coursework (written)	0	1

Events					
SS 2019	4060231	Inversion and Tomography	2 SWS	Lecture (V)	Ritter, Gaßner
SS 2019	4060232	Exercises to Inversion and Tomography	2 SWS	Practice (Ü)	Ritter, Gaßner

T 4.25 Course: Master Thesis [T-PHYS-103350]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101730 - Modul Master Thesis

Type	Credits	Version
Final Thesis	30	1

Final Thesis
This course represents a final thesis. The following periods have been supplied:

Submission deadline	6 months
Maximum extension period	3 months
Correction period	8 weeks

This thesis requires confirmation by the examination office.

T 4.26 Course: Measuring Methods in Physical Volcanology, exam [T-PHYS-103671]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101950 - Measuring Methods in Physical Volcanology, graded

Type	Credits	Version
Oral examination	1	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103570 - Measuring Methods in Physical Volcanology, Prerequisite must have been passed.

T 4.27 Course: Measuring Methods in Physical Volcanology, Prerequisite [T-PHYS-103570]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: **M-PHYS-101871 - Measuring Methods in Physical Volcanology, not graded**
M-PHYS-101950 - Measuring Methods in Physical Volcanology, graded

Type	Credits	Version
Completed coursework	1	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course **T-PHYS-103553 - Introduction to Volcanology, Prerequisite** must have been passed.

T 4.28 Course: Modern Physics Laboratory Courses [T-PHYS-102291]

Responsible: Dr. Andreas Naber
Organisation: KIT Department of Physics
Part of: M-PHYS-101355 - Modern Physics Laboratory Course

Type	Credits	Recurrence	Version
Completed coursework	6	Each term	1

Events					
SS 2019	4011313	Praktikum Moderne Physik (Kurs 1)	4 SWS	Practical course (P)	Naber, Guigas, Sürgers, Wolf
SS 2019	4011323	Praktikum Moderne Physik (Kurs 2)	4 SWS	Practical course (P)	Naber, Guigas, Sürgers, Wolf
WS 19/20	4011313	Praktikum Moderne Physik (Kurs 1)	4 SWS	Practical course (P)	Naber, Guigas, Sürgers, Wolf
WS 19/20	4011323	Praktikum Moderne Physik (Kurs 2)	4 SWS	Practical course (P)	Naber, Guigas, Sürgers, Wolf

Prerequisites
none

T 4.29 Course: Near Surface Geophysical Prospecting, Prerequisite [T-PHYS-103645]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101946 - Near Surface Geophysical Prospecting

Type	Credits	Version
Completed coursework	1	1

T 4.30 Course: Near-surface seismic and GPR [T-PHYS-107793]

Responsible: Prof. Dr. Thomas Bohlen
Yudi Pan

Organisation: KIT Department of Physics

Part of: M-PHYS-103855 - Near-surface seismic and GPR

Type	Credits	Recurrence	Version
Completed coursework	6	Each winter term	1

Events					
WS 19/20	4060151	Near-surface seismic and GPR	1 SWS	Lecture (V)	Bohlen, Pan
WS 19/20	4060152	Exercises on Near-surface seismic and GPR	1 SWS	Practice (Ü)	Bohlen, Pan, NN

T 4.31 Course: Physics of Seismic Instruments, Prerequisite [T-PHYS-102325]

Responsible: Dr. Thomas Forbriger
Organisation: KIT Department of Physics
Part of: M-PHYS-101358 - Seismometry, Signal Processing and Seismogram Analysis

Type	Credits	Version
Completed coursework (written)	0	1

Events					
WS 19/20	4060051	Physics of seismic instruments	2 SWS	Lecture (V)	Forbriger
WS 19/20	4060052	Exercise on physics of seismic instruments	1 SWS	Practice (Ü)	Forbriger, Ciesielski, Rietbrock

T 4.32 Course: Physics of the Lithosphere, exam [T-PHYS-103678]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101960 - Physics of the Lithosphere, graded

Type	Credits	Version
Examination of another type	1	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-103574 - Physics of the Lithosphere, Studienleistung must have been passed.

T 4.33 Course: Physics of the Lithosphere, Studienleistung [T-PHYS-103574]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101875 - Physics of the Lithosphere, not graded
M-PHYS-101960 - Physics of the Lithosphere, graded

Type	Credits	Version
Completed coursework	2	1

T 4.34 Course: Recent Geodynamics [T-BGU-101771]

Responsible: Dr. Malte Westerhaus
Organisation: KIT Department of Civil Engineering, Geo- and Environmental Sciences
Part of: M-BGU-101030 - Recent Geodynamics

Type	Credits	Version
Oral examination	3	1

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-BGU-101772 - Recent Geodynamics, Prerequisite must have been passed.

T 4.35 Course: Recent Geodynamics, Prerequisite [T-BGU-101772]

Responsible: Dr. Malte Westerhaus
Organisation: KIT Department of Civil Engineering, Geo- and Environmental Sciences
Part of: M-BGU-101030 - Recent Geodynamics

Type	Credits	Version
Completed coursework	1	1

T 4.36 Course: Scientific Seminars [T-PHYS-102335]

Organisation: KIT Department of Physics
Part of: M-PHYS-101357 - Scientific Seminars

Type	Credits	Recurrence	Version
Completed coursework	4	Each term	1

Events					
WS 19/20	4060294	Institutsseminar	2 SWS	Seminar (S)	Bohlen, Rietbrock
WS 19/20	6020730	Geodätisches Kolloquium	1 SWS	Colloquium (KOL)	Breunig, Hinz, Hennes, Kutterer
WS 19/20	6339044	Geologisches Fachgespräch für Diplomanden, Doktoranden und Gäste	2 SWS	Lecture (V)	Dozenten der Geowissenschaften

Prerequisites
none

T 4.37 Course: Seismic Data Processing, coursework [T-PHYS-108686]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104186 - Seismic Data Processing with final report (graded)
M-PHYS-104188 - Seismic Data Processing with final report (ungraded)
M-PHYS-104189 - Seismic Data Processing without final report (ungraded)

Type	Credits	Version
Completed coursework	2	1

T 4.38 Course: Seismic Data Processing, final report (graded) [T-PHYS-108656]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104186 - Seismic Data Processing with final report (graded)

Type	Credits	Version
Examination of another type	4	1

Events					
SS 2019	4060321	Seismic Data Processing	1 SWS	Lecture (V)	Bohlen, Hertweck, Athanasopoulos
SS 2019	4060322	Exercises to Seismic Data Processing	2 SWS	Practice (Ü)	Bohlen, Hertweck, Athanasopoulos

Prerequisites
Successfull participoation on "Seismic Data Processing, course achievement"

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-108686 - Seismic Data Processing, coursework must have been passed.

T 4.39 Course: Seismic Data Processing, final report (ungraded) [T-PHYS-108657]

Responsible: Prof. Dr. Thomas Bohlen
Dr. Thomas Hertweck

Organisation: KIT Department of Physics

Part of: M-PHYS-104188 - Seismic Data Processing with final report (ungraded)

Type	Credits	Version
Completed coursework	4	1

Prerequisites
Successfull participoation on "Seismic Data Processing, course achievement"

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-108686 - Seismic Data Processing, coursework must have been passed.

4.40 Course: Seismic Modelling, Prerequisite [T-PHYS-108636]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101359 - Theory and Inversion of Seismic Waves

Type	Credits	Version
Completed coursework (written)	0	1

Events					
SS 2019	4060261	Seismic Modelling	1 SWS	Lecture (V)	Bohlen, Pan
SS 2019	4060262	Exercises to Seismic Modelling	1 SWS	Practice (Ü)	Bohlen, Pan

T 4.41 Course: Seismics, Prerequisite [T-PHYS-109266]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101358 - Seismometry, Signal Processing and Seismogram Analysis

Type	Credits	Version
Completed coursework (written)	0	1

Events					
WS 19/20	4060111	Seismics	2 SWS	Lecture (V)	Bohlen, Hertweck
WS 19/20	4060112	Exercises on Seismics	2 SWS	Practice (Ü)	Hertweck, Bohlen, Athanasopoulos

T 4.42 Course: Seismology, Prerequisite [T-PHYS-109267]

Responsible: Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: M-PHYS-101358 - Seismometry, Signal Processing and Seismogram Analysis

Type	Credits	Version
Completed coursework (written)	0	1

Events					
WS 19/20	4060171	Seismology	2 SWS	Lecture (V)	Rietbrock, Gottschämmer
WS 19/20	4060172	Exercises on Seismology	2 SWS	Practice (Ü)	Rietbrock, Gottschämmer, Gaßner

T 4.43 Course: Seismometry, Signal Processing and Seismogram Analysis, Exam [T-PHYS-106217]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101358 - Seismometry, Signal Processing and Seismogram Analysis

Type	Credits	Recurrence	Version
Oral examination	22	Each winter term	2

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-102325 - Physics of Seismic Instruments, Prerequisite must have been passed.
2. The course T-PHYS-109266 - Seismics, Prerequisite must have been passed.
3. The course T-PHYS-109267 - Seismology, Prerequisite must have been passed.

T 4.44 Course: Seminar on Recent Topics of Applied Geophysics [T-PHYS-107675]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101360 - Scientific Focusing Phase

Type	Credits	Recurrence	Version
Completed coursework (oral)	10	Each term	1

Events					
SS 2019	4060284	Seminar on Applied Geophysics	2 SWS	Seminar (S)	Bohlen, Hertweck
WS 19/20	4060234	Seminar on Applied Geophysics	2 SWS	Seminar (S)	Bohlen, Hertweck

T 4.45 Course: Seminar on Recent Topics of General Geophysics [T-PHYS-107676]

Responsible: Dr. Ellen Gottschämmer
Prof. Dr. Andreas Rietbrock
Organisation: KIT Department of Physics
Part of: M-PHYS-101360 - Scientific Focusing Phase

Type	Credits	Recurrence	Version
Completed coursework (oral)	10	Each term	1

Events					
SS 2019	4060274	Current Topics in Seismology and Hazard	2 SWS	Seminar (S)	Rietbrock
WS 19/20	4060274	Current Topics in Seismology and Hazard	2 SWS	Seminar (S)	Rietbrock, Gottschämmer

T 4.46 Course: Seminar on Recent Topics of Risk Science [T-PHYS-107673]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-103803 - Seminar on recent topics of risk science

Type	Credits	Recurrence	Version
Completed coursework	4	Each winter term	1

Events					
WS 19/20	4060284	Seminar über aktuelle Themen aus der Risikoforschung (Literaturseminar)	2 SWS	Seminar (S)	Gottschämmer

T 4.47 Course: Seminar Seismological Analysis [T-PHYS-110593]

Responsible: Prof. Dr. Joachim Ritter
Organisation: KIT Department of Physics
Part of: M-PHYS-101360 - Scientific Focusing Phase

Type	Credits	Recurrence	Version
Completed coursework (oral)	10	Each term	1

Events					
WS 19/20	4060244	Seminar Seismological Analysis	2 SWS	Seminar (S)	Ritter

T 4.48 Course: Structural Geology and Tectonics [T-BGU-103712]

Responsible: Prof. Dr. Agnes Kontny
Organisation: KIT Department of Civil Engineering, Geo- and Environmental Sciences
Part of: M-BGU-101996 - Structural Geology and Tectonics

Type	Credits	Version
Written examination	4	1

Events					
WS 19/20	6339009	Strukturgeologie und Tektonik	3 SWS	Lecture / Practice (VÜ)	Kontny

Prerequisites
none

T 4.49 Course: The Black Forest Observatory at Schiltach, Prerequisite [T-PHYS-103569]

Responsible: Dr. Ellen Gottschämmer
Organisation: KIT Department of Physics
Part of: M-PHYS-101870 - The Black Forest Observatory at Schiltach

Type	Credits	Version
Completed coursework	1	1

Events					
SS 2019	4060403	In Situ: Das geowissenschaftliche Gemeinschaftsobservatorium bei Schiltach	1 SWS	Lecture (V)	Gottschämmer, Forbriger

T 4.50 Course: Theory and Inversion of Seismic Waves, Exam [T-PHYS-106218]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101359 - Theory and Inversion of Seismic Waves

Type	Credits	Version
Oral examination	18	2

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-PHYS-102330 - Theory of Seismic Waves, Prerequisite must have been passed.
2. The course T-PHYS-102332 - Inversion and Tomography, Prerequisite must have been passed.
3. The course T-PHYS-108636 - Seismic Modelling, Prerequisite must have been passed.

T 4.51 Course: Theory of Seismic Waves, Prerequisite [T-PHYS-102330]

Responsible: Prof. Dr. Thomas Bohlen
Organisation: KIT Department of Physics
Part of: M-PHYS-101359 - Theory and Inversion of Seismic Waves

Type	Credits	Version
Completed coursework (written)	0	1

Events					
SS 2019	4060221	Theory of Seismic Waves	2 SWS	Lecture (V)	Bohlen, Hertweck
SS 2019	4060222	Exercises to Theory of Seismic Waves	1 SWS	Practice (Ü)	Bohlen, Hertweck

T 4.52 Course: Wildcard [T-PHYS-104677]

Organisation: University
Part of: M-PHYS-102349 - Interdisciplinary Qualifications

Type	Credits	Version
Completed coursework	2	1

T 4.53 Course: Wildcard [T-PHYS-106253]

Organisation: University
Part of: M-PHYS-103142 - Module Wildcard Electives

Type	Credits	Version
Completed coursework	2	1

T 4.54 Course: Wildcard [T-PHYS-106249]

Organisation: University
Part of: M-PHYS-103142 - Module Wildcard Electives

Type	Credits	Version
Examination of another type	2	1

T 4.55 Course: Wildcard [T-PHYS-104675]

Organisation: University
Part of: M-PHYS-102349 - Interdisciplinary Qualifications

Type	Credits	Version
Examination of another type	2	1

T 4.56 Course: Wildcard Additional Examinations 1 [T-PHYS-103898]

Organisation: University
Part of: M-PHYS-102020 - Further Examinations

Type	Credits	Version
Completed coursework	2	1

T 4.57 Course: Wildcard Additional Examinations 11 [T-PHYS-103937]

Organisation: University
Part of: M-PHYS-102020 - Further Examinations

Type	Credits	Version
Examination of another type	2	1