Course Catalogue
Master Geophysics

Master of Science, M.Sc.
(120 ECTS points)

According to the Examination Regulations
as of 30 October 2007
88/066/—/M0/H/2007

The master's programme is jointly offered by
Ludwig-Maximilians-Universität München
and Technische Universität München.

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1 Abbreviations and Remarks

CP	Credit Point(s), ECTS Point(s)
ECTS	European Credit Transfer and Accumulation System
h	hours
SS	summer semester
WS	winter semester
SWS	credit hours

1. Please note: The course catalogue serves as an orientation only for your course of study. For binding regulations please consult the official examination regulations. These can be found at:
   www.lmu.de/studienangebot for the respective programme of study.

2. In the description of the associated module components ECTS points in brackets are for internal use only. ECTS points without brackets are awarded for passing the corresponding examination.

3. Modules whose identifier starts with P are mandatory modules. Modules whose identifier starts with WP are elective modules.

2 Module: P 1 Fundamentals from Mathematics and Physics

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	P 1.1 Mathematical Geophysics (lecture)	WS	60 h (4 SWS)	120 h	6
exercise	P 1.2 Mathematical Geophysics (exercise)	WS	30 h (2 SWS)	30 h	2
lecture	P 1.3 Statistical Geophysics (lecture)	WS	30 h (2 SWS)	60 h	3
exercise	P 1.4 Statistical Geophysics (exercise)	WS	15 h (1 SWS)	15 h	1
lecture	P 1.5 Earth Rotation and Solid Earth Physics (lecture)	WS	45 h (3 SWS)	75 h	4
exercise	P 1.6 Earth Rotation and Solid Earth Physics (exercise)	WS	30 h (2 SWS)	30 h	2

18 ECTS points are awarded for this module. The attendance time is 14 hours a week. Including self-study, there are about 540 hours to be dedicated to the module.

Type	compulsory module with compulsory module components
Usability within other programmes	none
Selection rules	none
Entry requirements	none
Level	1st semester
Duration	one semester
Assessment	sub-module examination: written exams (duration 90 - 120 minutes) or oral exams (duration 30 minutes)
Grading	the module is marked
Module coordinator	Dr. Marcus Mohr, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München

Teaching language	English
Remarks	none

Content

This module provides in-depth knowledge of basic mathematical methods like multidimensional analysis, optimization and approximation theory as well as physical modelling. Additionally, the module teaches fundamentals of statistical methods which were essential for processing observational data. The module provides advanced models of the structure of the earth, the materials and processes as well as possibles observables for these models.

P 1.1/1.2 Mathematical Geophysics

- coordinate systems (polar, cylindrical, spherical coordinates)
- vector analysis (differential operators and central theorems)
- partial differential equations (modelling, classification, characterization, properties, classical solution methods)
- Green's functions
- normal modes and special functions (Bessel and Legendre functions)
- approximation theory (Fourier series, spherical harmonics)
- literature:
  - Roel Snieder, A Guided Tour of Mathematical Methods for the Physical Sciences, Cambridge University Press
  - Yehuda Pinchover and Jacob Rubinstein, An Introduction to Partial Differential Equations, Cambridge University Press

P 1.3/1.4 Statistical Geophysics

- descriptive statistics
- probability theory (Bayes' theorem)
- distribution, expectation, variance
- statistical tests (t-test, independent and matched pairs samples, non-parametric methods)
- regression (linear regression, logistic regression, Poisson regression)
- practical exercises: programming language R, statistical computing
- literature:
  - Students receive a script with the content of the lecture.
  - Brian S. Everitt und Torsten Hothorn, A Hand-book of Statistical Analyses Using R, CRC Press

P 1.5/1.6 Earth Rotation and Solid Earth Physics

- advanced concepts of the internal structure of the earth
- influence on mass and heat transport
- properties of elastic materials and their high pressure and high temperature behaviour
- influence of large scale planetary dynamics on geodetic observables (gravity and rotation)
- literature:

- Brian Kennett und Hans-Peter Bunge, Geophysical Continua, Cambridge University Press

Qualification aims	The aim of the module is to provide students with theoretical foundations that are required for the understanding and critical interpretation of modern geophysical concepts. After successful participation of this module the qualified students should be in the position to understand and apply the mathematical and statistical concepts of modern geophysics. Furthermore, they will be able to deal with special topics of this scientific discipline critically in advanced modules. Students should be in the position to learn advanced scientific methods and techniques independently as well as to acquire and interpret geophysical problems.

3 Module: P 2 Basic Geophysics

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	P 2.1 Introduction to Earth System Science (lecture)	WS	60 h (4 SWS)	120 h	6
lecture	P 2.2 Physical properties of rocks (lecture)	WS	30 h (2 SWS)	90 h	4
exercise	P 2.3 Physical properties of rocks (exercise)	WS	30 h (2 SWS)	30 h	2
lecture	P 2.4 Geophysical Data Acquisition and Analysis (lecture)	SS	45 h (3 SWS)	135 h	6

18 ECTS points are awarded for this module. The attendance time is 11 hours a week. Including self-study, there are about 540 hours to be dedicated to the module.

Type	compulsory module with compulsory module components
Usability within other programmes	none
Selection rules	none
Entry requirements	none
Level	1st semester
Duration	two semesters
Assessment	sub-module examination: P 2.1 written exam (duration 60 - 180 minutes) or oral exam (duration 20 - 60 minutes), P 2.2/P 2.3 written exam (duration 60 - 90 minutes) or oral exam (duration 30 minutes), P 2.4 scientific report: circa 7500 words) and presentation (duration 30 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Heiner Igel, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English

Remarks The course "Introduction to Earth System Science" is part of the master's programme Earth Oriented Space Science (ESPACE) of the Technische Universität München

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Content The content of this module concentrates on the use of physical methods to solve problems in geosciences at various spatial and temporal scales. The module focuses on the introduction and interaction of the different systems involved (atmosphere, oceans, earth's interior) as well as the internal structure of the earth. Furthermore, the module teaches complex models of the deformation behaviour of rocks and data acquisition and processing techniques.

P 2.1 Introduction to Earth System Science

- components of earth systems (atmosphere, oceans, cryosphere, solid earth)
- processes in these systems and their interaction
- geophysical and geochemical parameters and internal and external forces (gravitational and magnetic forces, tides)
- fundamentals of modelling as well as methods and sensors for earth observation from space

P 2.2/2.3 Physical properties of rocks

- advanced concepts of deformation behaviour of rocks
- relationship between stress and strain
- advanced rheological concepts applied to a wide range of deformation time-scales
- development of rock structures on the micro and meso scale
- consequences of these concepts on the deformation history of tectonic units

P 2.4 Geophysical Data Acquisition and Analysis

- geophysical measurements (seismic, magnetic and gravitational)
- fundamentals of spectral analysis
- fundamentals of filter theory
- fundamentals of geophysical instruments
- calibration of geophysical instruments and correction of instruments

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Qualification aims The aim of the module is to expose students to the large spectrum of processes involved in geophysical research. With this knowledge students have the abilities to understand the process-related complexity as well as to identify and interpret the related components.

Furthermore, after successful participation in this module students are in the position to solve specific geophysical problems by using essential techniques (for example seismic methods, magnetic methods or geoelectrical methods). The students are able to describe the physical fundamentals of these geophysical methods. Moreover, students are in the position to understand and explain the relationship between structure and properties of rocks and geophysical processes. Students know and are able to apply the common methods and analytic techniques of data collection in the earth sciences. Students know the fundamentals of data acquisition and spectral analysis and they are in the position to edit, analyze and interpret geoscientific data by the use of computational processes.

4 Module: P 3 Tools

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	P 3.1 Computational Geophysics (lecture)	SS	30 h (2 SWS)	90 h	4
exercise	P 3.2 Computational Geophysics (exercise)	SS	30 h (2 SWS)	30 h	2
lecture	P 3.3 Scientific Programming (lecture)	SS	30 h (2 SWS)	60 h	3
exercise	P 3.4 Scientific Programming (exercise)	SS	30 h (2 SWS)	30 h	2
lecture	P 3.5 Signal Processing (lecture)	SS	30 h (2 SWS)	60 h	3
exercise	P 3.6 Signal Processing (exercise)	SS	15 h (1 SWS)	15 h	1

15 ECTS points are awarded for this module. The attendance time is 11 hours a week. Including self-study, there are about 450 hours to be dedicated to the module.

Type	compulsory module with compulsory module components
Usability within other programmes	none
Selection rules	none
Entry requirements	none
Level	2nd semester
Duration	two semesters
Assessment	sub-module examination: P 3.1 written exams (P 3.1/P 3.2 and P 3.3/P 3.4 duration 60 - 180 minutes and P 3.5/P 3.6 duration 45-90 minutes) or oral exam (duration 30 minutes)
Grading	the module is marked
Module coordinator	Dr. Marcus Mohr, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München

Teaching language	English
Remarks	none

Content

The courses of this module teaches broad basic knowledge of three fields essential for the application of computers for geophysical research. These are firstly algorithms from numerical mathematics that are used to evaluate and simulate physical models on computers. Secondly the courses deal with efficient and correct implementation of such algorithms on computer systems and thirdly the module teaches methods from the field of signal processing.

P 3.1/P 3.2 Computational Geophysics

- basics of numerical algorithms, (asymptotical) complexity
- rounding error analysis, condition numbers
- polynomial interpolation
- data fitting and least squares problems
- discretisation methods for partial differential equations
- literature:
  - Students receive a script with the content of the lecture.

P 3.3/P 3.4 Scientific programming

- fundamentals and architecture of modern computer systems
- history and classification of programming languages
- representation of numerical data on computer systems
- programming in Fortran
- classical & special data structures for scientific computing, selected algorithms
- automated build-tools and version control
- preprocessing
- literature:
  - Students receive a script with the content of the lecture.

P 3.5/P 3.6 Signal processing

- use of complex numbers in the field of signal processing
- signals in time, space and frequency domain (continuous, discrete)
- convolution of signals
- linear time invariant systems
- random signals, reconstruction of signals and interpolation
- literature:
  - Bracewell, RN, The Fourier Transform and its Applications, McGraw Hill, New York, 1965
  - Marko H, Methoden der Systemtheorie, Springer, 1982
  - Hänsler E, Statistische Signale, Springer, 1997
  - Gaskill JD, Linear Systems, Fourier Transforms, and Optics, John Wiley & Sons, 1976

Qualification aims	After successful participation in this module students are in the position to implement standard geophysical models on computer systems, compare and evaluate different such implementations and apply standard software packages for numerical simulations and signal processing. In addition, students are able to explain advanced theoretical basics of system theory and understand the interaction between space/time and frequency domain. Students are able to evaluate and interpret data sets using methods of signal processing.

5 Module: P 4 Advanced Geophysics

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	P 4.1 Geodynamics (lecture)	SS	30 h (2 SWS)	60 h	3
lecture	P 4.2 Seismology (lecture)	SS	30 h (2 SWS)	60 h	3
lecture	P 4.3 Paleo- & Geomagnetism (lecture)	SS	15 h (1 SWS)	45 h	2
exercise	P 4.4 Paleo- & Geomagnetism (exercise)	SS	15 h (1 SWS)	15 h	1

9 ECTS points are awarded for this module. The attendance time is 6 hours a week. Including self-study, there are about 270 hours to be dedicated to the module.

Type	compulsory module with compulsory module components
Usability within other programmes	none
Selection rules	none
Entry requirements	none
Level	2nd semester
Duration	one semester
Assessment	written exam (duration 90 - 120 minutes) or oral exam (duration 30 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Hans-Peter Bunge, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English
Remarks	none

Content

This module teaches students modern quantitative methods, descriptions and applications of geophysical processes, including potential methods, partial differential equations, numerical simulation of complex (non-linear) geophysical processes by use of modern high-performance computing and data processing methods including concepts of data assimilation, optimization and inversion.

P 4.1 Geodynamics

- modern concepts of fluid dynamics
- their relevance for the internal structure and dynamics of the earth
- geological and geodetical constraints on the structure and evolution of the deep earth

P 4.2 Seismology

- inverse problems in geophysics and seismology
- theory of linear inverse problems
- specifications and conditions
- modelling of measuring errors and faults
- least squares optimization
- methods of regularization (Tikhonov)
- exercises on the computer: localization of earthquakes
- exercises on the computer: seismic tomography
- literature:
  - Menke, Geophysical Data Analysis: Discrete Inverse Theory, Academic Press

P 4.3/4.4 Geo- and Paleomagnetism

- origin of magnetic remanence
- information from magnetic signatures in rocks (reversal frequency, secular variation, continental drift, pole wandering, other geological phenomena)
- observatory and satellite observations of historic earth's field
- field excursion and laboratory work (drill and orient cores, determine their magnetic remanence, interpret data)

Qualification aims

Students will develop an up-to-date detailed and critical understanding in the fields of geophysics (geodynamics, seismology, geo- and paleomagnetism). They are able to define and interpret characteristics, limits, terminology and experts' opinions in the geophysical fields.

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6 Module: WP 1 Advanced Geodynamics

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	WP 1.1 Modern Geodynamics	SS	30 h (2 SWS)	60 h	3
lecture	WP 1.2 Interdisciplinary Geophysics 1	WS	30 h (2 SWS)	30 h	2
colloquium	WP 1.3 Geophysics Colloquium 1	SS	15 h (1 SWS)	15 h	1
seminar	WP 1.4 Special Topics in Geodynamics	WS	30 h (2 SWS)	90 h	4
exercise	WP 1.5 Techniques of Scientific Working 1	WS	30 h (2 SWS)	30 h	2

12 ECTS points are awarded for this module. The attendance time is 9 hours a week. Including self-study, there are about 360 hours to be dedicated to the module.

Type	elective module with compulsory module components
Usability within other programmes	none
Selection rules	students have to choose one module from WP 1 – WP 3
Entry requirements	none
Level	2nd semester (recommended)
Duration	two semesters
Assessment	written exam (duration 90 - 120 minutes) or oral exam (duration 30-60 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Hans-Peter Bunge, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English

Remarks none

Content This module enables students to understand a wide range of geophysical and geological observations in the context of the underlying geodynamical processes. Special emphasis is placed on global processes both in the crust an the deeper earth, and connection to the similar processes in the terrestrial planets are drawn when ever possible.

WP 1.1 Modern Geodynamics

- quantitative concepts on fluid and elasto dynamics
- spatial and temporal scales of internal earth deformation
- relevant non-dimensional numbers
- geological and geodetic constraints to infer the structure of evolution of the deep earth

WP 1.2 Interdisciplinary Geophysics 1

Students can choose this course out of varying offer of scientific presentations. The content depends on the focus of the special presentations and includes topics from geo- and paleomagnetism, seismology, rocks and mineral physics, risk analysis as well as geodynamics. Topics focus on quantitative methods and technical concepts that are used to describe the earth magnetic field, tectonic deformation and seismic wave propagation. Special emphasis is placed on the interdisciplinary cross-links between the fields involved.

WP 1.3 Geophysical Colloquium 1

This colloquium consists of a number of presentations by varying scientists. Its function is to introduce students to the wide range of current day research topics in the geosciences both at the Department of Earth and Environmental Siences and internationally. This will prepare them for choosing a topic for their master thesis and a potential subsequent doctoral project.

WP 1.4 Special Topics in Geodynamics

This course deals with up-to-date topics in the geodynamic literature. The aim of the course is to introduce students to research work currently done by members of the geodynamics group in order to prepare them for their master thesis and a potential later doctoral project.

WP 1.5 Techniques of Scientific Working 1

This course teaches students practical and soft skills required for conducting and presenting scientifc work. Topics include scientific writing of a paper (technically and concerning contents), how to prepare and give a scientific presentation, as well as aspects of doing literature research and using geophysical data bases. The students obtain knowledge for conducting their master thesis.

Qualification aims After successful participation in this module students are in the position to conduct independent scientific work in the field of geodynamics. Students are able to integrate complex concepts of modern geodynamics and apply their knowledge to current research topics. They are qualified to conduct scientific work, adequately reference previous scientific results and present their results in oral and written form.

7 Module: WP 2 Advanced Seismology

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	WP 2.1 Modern Seismology	SS	30 h (2 SWS)	60 h	3
lecture	WP 2.2 Interdisciplinary Geophysics 2	WS	30 h (2 SWS)	30 h	2
colloquium	WP 2.3 Geophysics Colloquium 2	SS	15 h (1 SWS)	15 h	1
seminar	WP 2.4 Special Topics in Seismology	WS	30 h (2 SWS)	90 h	4
exercise	WP 2.5 Techniques of Scientific Working 2	WS	30 h (2 SWS)	30 h	2

12 ECTS points are awarded for this module. The attendance time is 9 hours a week. Including self-study, there are about 360 hours to be dedicated to the module.

Type	elective module with compulsory module components
Usability within other programmes	none
Selection rules	students have to choose one module from WP 1 – WP 3
Entry requirements	none
Level	2nd semester (recommended)
Duration	two semesters
Assessment	written exam (duration 90 - 120 minutes) or oral exam (duration 30-60 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Heiner Igel, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English

Remarks none

Content

This module teaches students an overview of current scientific research in seismology and the application of seismological methods to solve complex problems in relation with seismic sources and the reconstruction of the internal structure of the earth.

WP 2.1 Modern Seismology

- linear elasticity theory
- theoretical fundamentals of the seismic wave propagation
- physical concepts of earthquake source
- mathematical methods to calculate the run-time of waves and seismograms
- numerical solutions of the elastic wave equation
- special topics of seismology and their methodical relations

WP 2.2 Interdisciplinary Geophysics 2

Students can choose this course out of varying offer of scientific presentations. The content depends on the focus of the special presentations and includes topics from geo- and paleomagnetism, seismology, rocks and mineral physics, risk analysis as well as geodynamics. Topics focus on quantitative methods and technical concepts that are used to describe the earth magnetic field, tectonic deformation and seismic wave propagation. Special emphasis is placed on the interdisciplinary cross-links between the fields involved.

WP 2.3 Geophysical Colloquium 2

This colloquium consists of a number of presentations by varying scientists. Its function is to introduce students to the wide range of current day research topics in the geosciences both at the Department of Earth and Environmental Siences and internationally. This will prepare them for choosing a topic for their master thesis and a potential subsequent doctoral project.

WP 2.4 Special Topics in Seismology

This course deals with up-to-date topics in the seismic literature. The aim of the course is to introduce students to research work currently done by members of the seismology group in order to prepare them for their master thesis and a potential later doctoral project.

WP 2.5 Techniques of Scientific Working 2

This course teaches students practical and soft skills required for conducting and presenting scientifc work. Topics include scientific writing of a paper (technically and concerning contents), how to prepare and give a scientific presentation, as well as aspects of doing literature research and using geophysical data bases. The students obtain knowledge for conducting their master thesis.

Qualification aims

After successful participation in this module students are in the position to conduct independent scientific work in the field of seismology. Students are able to deal with seismological observations, interpret the results and apply their knowledge to current research topics in the geosciences. They understand inversion problems for seismic sources and the structure of the geophysical parameters of the internal earth. Students are qualified to conduct scientific work, adequately reference previous scientific results and present their results in oral and written form.

8 Module: WP 3 Advanced Paleo- and Geomagnetism

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	WP 3.1 Modern Paleo- and Geomagnetism	SS	30 h (2 SWS)	60 h	3
lecture	WP 3.2 Interdisciplinary Geophysics 3	WS	30 h (2 SWS)	30 h	2
colloquium	WP 3.3 Geophysics Colloquium 3	SS	15 h (1 SWS)	15 h	1
seminar	WP 3.4 Special Topics in Paleo- and Geomagnetism	WS	30 h (2 SWS)	90 h	4
exercise	WP 3.5 Techniques of Scientific Working 3	WS	30 h (2 SWS)	30 h	2

12 ECTS points are awarded for this module. The attendance time is 9 hours a week. Including self-study, there are about 360 hours to be dedicated to the module.

Type	elective module with compulsory module components
Usability within other programmes	none
Selection rules	students have to choose one module from WP 1 – WP 3
Entry requirements	none
Level	2nd semester (recommended)
Duration	two semesters
Assessment	written exam (duration 90 - 120 minutes) or oral exam (duration 30-60 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Stuart Gilder, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English

Remarks none

Content

This module enables students to understand a wide range of processes in rock magnetism and geo- and paleomagnetism. This includes the understanding of the origin of remanent magnetism in rocks and minerals, the formation of magnetic fields, temporal changes of the magnetic field of the earth, the basics of paleogeographical reconstruction and the application of methods of paleomagnetism to solve tectonical problems.

WP 3.1 Modern Paleo- and Geomagnetism

- magnetism in solids (diamagnetism, paramagnetism, ferromagnetism)
- quantification of magnetic properties of minerals and rocks (single- vs. multi-domain, grainsize, oxidation)
- origin and stability of remanent magnetism of rocks
- use of methods of paleomagnetism based on the remanent magnetism of rocks to understand geological processes (plate tectonics, mountain forming)
- quantification of historical and current fields by the use of mathematical and experimental methods

WP 3.2 Interdisciplinary Geophysics 3

Students can choose this course out of varying offer of scientific presentations. The content depends on the focus of the special presentations and includes topics from geo- and paleomagnetism, seismology, rocks and mineral physics, risk analysis as well as geodynamics. Topics focus on quantitative methods and technical concepts that are used to describe the earth magnetic field, tectonic deformation and seismic wave propagation. Special emphasis is placed on the interdisciplinary cross-links between the fields involved.

WP 3.3 Geophysical Colloquium 3

This colloquium consists of a number of presentations by varying scientists. Its function is to introduce students to the wide range of current day research topics in the geosciences both at the Department of Earth and Environmental Siences and internationally. This will prepare them for choosing a topic for their master thesis and a potential subsequent doctoral project.

WP 3.4 Special Topics in Paleo- and Geomagnetism

This course deals with up-to-date topics in the geo- and paleomagnetic literature. The aim of the course is to introduce students to research work currently done by members of the magnetism group in order to prepare them for their master thesis and later on doctoral project.

WP 3.5 Techniques of Scientific Working 3

This course teaches students practical and soft skills required for conducting and presenting scientifc work. Topics include scientific writing of a paper (technically and concerning contents), how to prepare and give a scientific presentation, as well as aspects of doing literature research and using geophysical data bases. The students obtain knowledge for conducting their master thesis.

Qualification aims	After successful participation in this module students are in the position to conduct independent scientific work in the fields of rock magnetism and geo- and paleomagnetism. They know the fundamentals of magnetic fields on all temporal and length scales including origin of magnetic fields and physical concepts and methods. In addition, they are able to explain and quantify the physical processes in earth and planetary sciences. Students are qualified to conduct scientific work, adequately reference previous scientific results and present their results in oral and written form.

9 Module: WP 4 Geochemistry and Geomaterials

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	WP 4.1 Physics and Chemistry of Melts (lecture)	WS	30 h (2 SWS)	60 h	3
exercise	WP 4.2 Physics and Chemistry of Melts (exercise)	WS	15 h (1 SWS)	15 h	1
lecture	WP 4.3 Crust and Mantle Petrology (lecture)	WS	45 h (3 SWS)	75 h	4
exercise	WP 4.4 Crust and Mantle Petrology (exercise)	WS	15 h (1 SWS)	15 h	1

9 ECTS points are awarded for this module. The attendance time is 7 hours a week. Including self-study, there are about 270 hours to be dedicated to the module.

Type	elective module with compulsory module components
Usability within other programmes	none
Selection rules	students have to choose two modules from WP 4 – WP 6
Entry requirements	none
Level	3rd semester (recommended)
Duration	one semester
Assessment	sub-module examination: written exams (duration 60 - 120 minutes) or oral exams (duration 20-40 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Don Dingwell, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English

Remarks

The four courses of this module are part of the compulsory module "P 1 Basics in Petrology and Geochemistry" of the master's programme Geomaterials and Geochemistry which is a joint degree programme of Ludwig-Maximilians-Universität München and Technische Universität München.

Content

Geophysical processes are strongly dependent on material parameters and the composition of the earth. This module allows students to deepen their knowledge concerning physical and chemical properties of melts and the petrology of earth's crust and mantle. This allows them to improve their interpretation of geophysical observations and build more realistic simulation models.

WP 4.1/4.2 Physics and Chemistry of Melts
The two courses teach students knowledge in rheology and thermodynamics of glasses, liquids and magmas (the glass transition) and geologically important physical properties (density, viscosity, heat capacity, etc.). Techniques for their measurement, the effects of pressure, temperature and composition on these properties (especially volatile content), and the theoretical (thermodynamic) basis for current models of physical properties.

WP 4.3/4.4 Crust and Mantle Petrology
This course deals with the petrologic evolution of planet earth and leads students towards an understanding of the origin and evolution of igneous and metamorphic rocks through space and time. Main topics include, among others, protoplanets and chondrites, Earth differentiation, pressure and temperature gradients in the earth's crust and interior, magma generation (tholeiitic, alkalic and calc-alkalic series), igneous processes in different tectonic environments, partial melting in the mantle (from different reservoirs) and in the crust (under different P-T and H_2O conditions), processes modifying the initial composition of magmas, ascent and intrusions of magmas and changes of melting and metamorphic conditions with space and time.

Qualification aims

Students will develop an advanced knowledge and understanding of the above mentioned topics in physics and chemistry of melts and crust and mantle petrology. Students are able to describe, understand and interpret geochemistrical processes, and they are in the position to use their knowledge and apply it to geophysical problems.

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10 Module: WP 5 Applied and Industrial Geophysics

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	WP 5.1 Archaeological Prospection	WS	30 h (2 SWS)	60 h	3
lecture	WP 5.2 Engineering Geophysics	WS	30 h (2 SWS)	60 h	3
lecture	WP 5.3 Application of magnetic methods in practice	WS	15 h (1 SWS)	45 h	2
practical	WP 5.4 Application of magnetic methods in practice	WS	15 h (1 SWS)	15 h	1

9 ECTS points are awarded for this module. The attendance time is 7 hours a week. Including self-study, there are about 270 hours to be dedicated to the module.

Type	elective module with compulsory module components
Usability within other programmes	none
Selection rules	students have to choose two modules from WP 4 – WP 6
Entry requirements	none
Level	3rd semester (recommended)
Duration	one semester
Assessment	module examination: written exam (duration 90 - 120 minutes) or oral exam (duration 30 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Stuart Gilder, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English
Remarks	none

Content

This module deals with the application of geophysical measurements and analytical techniques to problems important either in societal (environmental, archaeological) or industrial context.

WP 5.1 Archaeological Prospection

- history of geophysical prospection in the field of archaeology
- basic techniques and their archaeological interpretation: remote sensing, evaluation of aerial photography, digital image processing, distortion correction of slanted aerial photographs, LIDAR-scanning
- basics and application of geophysical instruments for archaeological field work (for example Cesium-magnetometer, fluxgate-gradiometer, radar systems)
- Introduction to magnetism of minerals with detailed focus on magnetism of soil and the properties of archaeological soils
- Presentation and discussion of examples and case studies of all archaeological time periods in Bavaria including Neolithic settlements, Iron Age, Roman period and Early Middle Ages.
- geophysical and archaeological interpretation of examples of very important archaeological sites in the world (Mesopotamia in Caucasus, Siberia, Middle East, Central Asia, South America and Easter Islands)

WP 5.2 Engineering Geophysics

- Application of modern geophysical methods like gravimetric, seismic, geoelectric methods, and radar
- practical introduction to these techniques in the field, interpretation of data and avoiding errors
- theoretical basics and physical parameters of the geophysical methods
- current examples and case studies in geothermal energy and hydrogeology (borehole geophysics), exploration of old pollution or investigation of rock slides

WP 5.3/5.4 Application of magnetic methods in practice

- introduction to magnetism and its origin
- theory of piezo-remanent magnetization (stress-induced transformation of magnetic properties)
- piezo remanent magnetization in the nature and their importance for the industry and society
- high pressure techniques with diamond press cells, laser and spectrometry
- magnetic methods with superconducting quantum interference device (SQUID) and vibrating sample magnetometer
- practical exercise: application of geophysical methods

Qualification aims

The aim of the module is to develop in-depth knowledge and obtain hands-on experience of applied geophysical methods, data acquisition, data interpretation and evaluation. After successful participation students are in the position to choose and apply the right geophysical method to solve corresponding problems as well as to evaluate and interpret the geophysical data.

Students are able to explain the societal importance of these geophysical techniques.

11 Module: WP 6 ESPACE

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	WP 6.1 Earth Gravity Field	WS	30 h (2 SWS)	60 h	3
lecture	WP 6.2 Precise GNSS	WS	30 h (2 SWS)	60 h	3
exercise	WP 6.3 Precise GNSS	WS	45 h (3 SWS)	45 h	3

9 ECTS points are awarded for this module. The attendance time is 7 hours a week. Including self-study, there are about 270 hours to be dedicated to the module.

Type	elective module with compulsory module components
Usability within other programmes	none
Selection rules	students have to choose two modules from WP 4 – WP 6
Entry requirements	none
Level	3rd semester (recommended)
Duration	one semester
Assessment	sub-module examinations: written exams (duration 90 - 120 minutes) or oral exams (duration 20-40 minutes)
Grading	the module is marked
Module coordinator	Prof. Dr. Urs Hugentobler, Faculty of Civil, Geo and Environmental Engineering, Technische Universität München
Teaching language	English
Remarks	The course "WP 6.2/6.3 Precise GNSS" is part of the master's degree programme Earth Oriented Space Science (ESPACE) offered by Technische Universität München. For the course "WP 6.1 Earth Gravity Field" students have two options. They can either choose the English-language course "Gravity and Magnetic Field from Space" that is part of the master's programme ESPACE. Alternatively

they can choose the German-language course "Schwerefeld und Satellitenmissionen" from the master's programme Geodäsie und Geoinformatik that is offered by Technische Universität München. The English-language course has as one of its key aspects the modelling of magnetic fields. In the German-language course this is replaced by a focus on satellite missions and altimetry.

Content

Satellite techniques gain more and more importance for earth science and engineering. This is especially true in geophysics where e.g. monitoring techniques based on Global navigation Satellite Systems (GNSS) based have a great influence in the areas of tectonics and geodynamics. This module allows students to obtain some basic knowledge in the field of earth oriented space science and gain experience in the usage of GNSS data.

WP 6.1 Earth Gravity Field

- methods for the determination of earth's global gravity field
- sources of gravity field data
- combined data and combined solutions
- quality analysis and validation
- satellite missions: gravity field, altimetry
- magnetometry
- future mission concepts
- literature:
  - Hofmann-Wellenhof B., Moritz H.: Physical Geodesy. Springer
  - Torge W.: Geodäsie. De Gruyter

WP 6.2/6.3 Precise GNSS

- operation and theory of GNSS and current systems (GPS, GLONASS, Galileo, BeiDou)
- analyzing and modelling methods for signal correction, solution methods for ambiguity problems and setting of reference systems
- application of high-precision GNSS in geodesy and geodynamic studies
- practical exercises with real-world GNSS data
- investigation of the influence of different effects and evaluation methods on position results by the use of advanced experiments with scientific evaluation software
- literature:
  - Hofmann-Wellenhof, Lichtenegger, Collins (2001): GPS-Theory and Practice, Springer
  - Mistra (2006): GPS-Signals, Measurements and Performance. Ganga-Jamuna Press
  - Teunissen, Kleusberg (Eds.) (1998): GPS for Geodesy. Springer
  - GPS Interface Control Document, ICD-GPS-200C
  - Bernese GPS Software Version 5.0 User Manual

Qualification aims

After successful participation in this module students are able to understand, interpret and describe the measuring and modelling methods of gravity fields as well as of GNSS analyses. Furthermore, they are familiar with competitive methods. Students are in the position to set up data sets independently as well as to evaluate and interpret existing scientific data sets.

12 Module: P 5 Independent Scientific Research

Part of Master Geophysics (Master of Science, M.Sc.)
Associated Module Components

Teaching	Component (compulsory)	Rota	Attendance	Selfstudy	ECTS
lecture	P 5.1 Master Thesis	WS/SS	—	810 h	27
lecture	P 5.2 Viva Voce	WS/SS	—	90 h	3

30 ECTS points are awarded for this module. The attendance time is 0 hours a week. Including self-study, there are about 900 hours to be dedicated to the module.

Type	compulsory module with compulsory module components
Usability within other programmes	none
Selection rules	none
Entry requirements	none
Level	4th semester
Duration	one semester
Assessment	Master thesis scientific report: circa 15.000 words, presentation of the Master thesis (45 minutes) and defence of Master thesis (15 minutes)
Grading	the module is marked
Module coordinator	Dr. Marcus Mohr, Department of Earth & Environmental Sciences, Ludwig-Maximilians-Universität München
Teaching language	English
Remarks	none
Content	This module consists of two parts. In the first part students are expected to perform independent scientific research on a complex problem of geophysics under the guidance of one or multiple advisors and to develop a new solution to the problem. In the second part the results of this research must

adequately be presented by writing a scientific work and giving an oral presentation as well as discussing the results obtained with colleagues and scientists from the field of geophysics.

Qualification aims	Students learn to transfer their advanced and technical knowledge in geophysics as well as their scientific competences in geophysics to a scientific research problem. They are able to solve a complex scientific problem independently, create, evaluate and interpret scientific data sets and write a scientific report. Students are in the position to discuss and present their results in front of a critical scientific audience.