# Study and Examination Regulations for the Master's Degree Program in Planetary Sciences and Space Exploration in the Department of Earth Sciences at Freie Universität Berlin

*[unofficial, preliminary version]*

*Disclaimer: Please note that only the German versions of these documents are legally binding. This translation is intended for the convenience of the non-German-reading public and is for information purposes only.*

## Preamble

On the basis of Section 14.1.1.2 of Freie Universität Berlin's supplemental rules and regulations *[Teilgrundordnung (Erprobungsmodell)]* from October 27, 1998, published in the Freie Universität bulletin No. 24/1998 (*FU-Mitteilungen*, the Department Council *(Fachbereichsrat)* of the Department of Earth Sciences at Freie Universität *Berlin* issued the following study and examination regulations for the master's degree program Planetary Sciences and Space Exploration in the Department of Earth Sciences on December 15, 2021[1]

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**Appendices:**



[1]The Executive Board of Freie Universität Berlin approved these regulations on January 14, 2022.

## Section 1
## Scope

(1) These regulations define the objectives, content, and structure of the master's degree program "Planetary Sciences and Space Exploration" at the Department of Earth Sciences at Freie Universität Berlin. These regulations apply in conjunction with Freie Universität Berlin's framework regulations for degree programs and examinations as they outline the requirements and processes necessary to complete coursework and assessments towards completion of a master's degree program.

(2) The degree program is a consecutive master's degree as defined by Section 23.3.1a BerlHG from July 26, 2011 (GVBl., p.378), last amended on September 14, 2021 (GVBl., p.1039).

## Section 2

## Learning Objectives

(1) Graduates of the master's degree have an advanced understanding of the problems and methods related to planetary sciences and space exploration. They are aware of the current field of research in relation to planetary bodies within and outside our solar system. They are familiar with the multiple ways in which satellites and space probes are used for remote sensing of the Earth and other planets, and have the knowledge to employ these methods. Their subject-specific and interdisciplinary skills in theory and methods meet internationally recognized standards. They are able to understand and critique complex scientific topics independently, and explain and discuss their own and other research findings in a way that is appropriate for the respective audience. They are able to apply their knowledge to new questions and to work in an international and interdisciplinary context. Graduates are aware of the foundations and basic general principles of scientific working and good scientific practice and are able to apply these from the start of their professional activities. They are equipped with subject-specific and conceptual strategies to resolve problems in the field of planetary sciences and remote sensing and are familiar with ways of working both in universities and non-university research institutes. Depending on their individual interests, graduates will also have gained special knowledge and skills in a selected area of their choice.

(2) Graduates are able to find an individual approach to subject-specific research projects and plan, structure, and conclude these successfully within a set time period. Along with their ability to apply subject-specific theoretical knowledge in practice, they also have communication and cooperation skills and are able to act responsibly and carry out scientific work independently. They also have social skills in the areas of interculturality, gender, and diversity. Additionally, graduates are able to lead discussions with a variety of groups on delimited and cross-disciplinary areas of their subject. They can use their skills to contribute positively to projects, can lead teams involved in complex research projects responsibly, and are able to critically reflect on and represent the findings of their research to others.

(3) Graduates of the master's degree are qualified to take up professional employment or to continue to doctoral study.
Possible professional fields include national or international research institutions (either in a university or a non-university context, e.g., the German Aerospace Center, Natural History Museum in Berlin), national and international space agencies (e.g., European Space Agency [ESA], National Aeronautics and Space Administration [NASA]), and in relevant industrial sectors with a focus on (aero)space, satellite technology, and remote sensing of the Earth.

They may also find employment in the area of management and organization, e.g., of space missions.

## Section 3

## Curriculum Contents

(1) The degree program includes a “synchronization” area that establishes a common foundation of knowledge for the master’s degree by ensuring that all students are familiar with areas that they may not have worked on in their respective bachelor’s degree programs. These areas include the foundations of geology insofar as these provide an understanding of terrestrial planets; the most important fundamental physical and chemical cycles necessary for the functioning of the Earth system in comparison with other planetary bodies; and the foundations of modern computer-based modeling and data analysis. In the “core” area of the degree program, students gain an understanding of the foundations of the planetary sciences, including how planets are created, and gain a knowledge of the skills and methods used in the remote sensing of Earth and the planets. They also learn the basic principles of planetary physics and how planetary atmospheres function and the consequences for planetary climates. The “specialization” area equips students with advanced, specialized, and applicable knowledge of skills and methods in relation to the various branches of planetary science (both within and outside our solar system) and in relation to the remote sensing of Earth and the planets. The degree program also includes modules in the area of professionalization and choosing a research specialty. Students are given insights into current research projects and the day-to-day work of researchers in university and non-university settings. Under supervision, students learn to carry out independent research that integrates the basic general principles of scientific working and good scientific practice.

(2) Students in the master’s degree program work both alone and in groups on subject-specific, relevant research topics. They plan targeted projects, implement these in accordance with given parameters within a set time period, and bring them to a successful conclusion. Students can access the knowledge they need independently, document their findings clearly, present these findings in a way that is appropriate to the respective audience, and critically analyze their own research. In the course of their studies, they will apply their skills and knowledge independently in international and intercultural groups. In practical exercises, they are able to support others in developing their subject-specific abilities. Depending on their individual interests, each student selects specific thematic areas to complete their own research profile.

## Section 4

## General Academic Advising and Departmental Advising

(1) The Center for Academic Advising and Psychological Counseling at Freie Universität Berlin provides general academic advising for students.

(2) Instructors who teach courses offered in the master’s degree program provide departmental advising during their office hours. A student assistant is also available to give additional advising support. Furthermore, students are advised to discuss the suitability of their individual curriculum plan with their program coordinator.

(3) In particular, students who have achieved less than one third of the credit points required for their studies shall be offered - no later than after the second semester - the opportunity to take part in subject advising sessions to promote a successful study programme.

## Section 5

## Examination Committee

The examination committee is appointed by the Department Council of the Department of Earth Sciences, Freie Universität Berlin. The committee is responsible for organizing examinations and the other tasks stipulated by the framework regulations for degree programs and examinations (RSPO).

## Section 6

## Standard Time to Degree

The standard time to degree is four semesters.

## Section 7

## Structure and Components; Distribution of Credit Points

(1) Students must earn 120 credit points (CP) in order to complete the master's degree program. The master's degree program comprises:

1. A synchronization area totaling 12 credit points
2. A core area totaling 43 credit points
3. A specialization area totaling 35 credit points and
4. The master's thesis, including participation in a colloquium and oral presentation of the thesis findings, totaling 30 credit points.

(2) The synchronization area totaling 12 CP establishes a common foundation for the master's degree by ensuring that all students are familiar with areas that they may not have worked on in their respective bachelor's degree programs. It includes the following modules:

- Module: Geological foundations (6 CP),
- Module: Computational methods (6 CP) and
- Module: Physical and mathematical foundations (6 CP).

To earn the mandatory 12 CP in this area, students are asked to complete modules according to the following criteria:

1. Students who earned fewer than 10 CP in geological sciences in their bachelor degree program must complete:
   - Module: Geological foundations (6 CP).

2. Students who earned fewer than 5 CP in the area of programming in their previous bachelor degree and do not have equivalent knowledge of programming from a non-university background must complete:
   - Module: Computational methods (6 CP).

3. Students to whom only 1. or 2. applies must complete the following module:
   - Module: Physical and mathematical foundations (6 CP).

4. Students to whom neither 1. nor 2. applies should select up to two modules from the synchronization area or equivalent modules, following mandatory consultation with the examinations committee.

(3) A core area totaling 43 credit points. The following modules are to be completed:
- Module: Introduction to planetary sciences and planet formation (9 CP),
- Module: Principles of GIS and remote sensing (6 CP),
- Module: Planetary physics (6 CP),
- Module: Planetary atmospheres and climate (6 CP),
- Module: Insights into current research (6 CP), and
- Module: Insights into the professional and research landscape (10 CP).

(4) In the specialization area, students may select from the following modules, totaling 35 credit points:
- Module: Planetary exploration: space missions (5 CP),
- Module: Planetary exploration: methods and instrumentation (5 CP),
- Module: Planetary surface processes and morphology (5 CP),
- Module: Advanced remote sensing of the Earth (10 CP),
- Module: Introduction to advanced geodata analysis (5 CP),
- Module: Celestial mechanics (5 CP),
- Module: The outer solar system (5 CP),
- Module: Magnetospheres (5 CP),
- Module: Satellite-based meteorology (10 CP),
- Module: Planetary evolution and habitability (5 CP),
- Module: Exoplanets (5 CP),
- Module: Geodynamical modelling of planets and moons (5 CP),
- Module: Numerical methods in geosciences and planetary sciences (5 CP),
- Module: Meteorites and the formation of terrestrial planets (5 CP),
- Module: Laboratory methods for the analysis of planetary materials (5 CP),
- Module: Planetary field trips (5 CP),
- Modul: Special topics of planetary sciences (5 CP),
- Modul: Special topics of space exploration (5 CP),
- Modul: Special topics of exploration of asteroids and other small bodies (5 CP),
- Modul: Special topics of geology (5 CP),
- Modul: Special topics of atmospheric sciences (5 CP), and
- Modul: Special topics of remote sensing (5 CP).

The choice of alternative modules from other areas can be requested. To do so, please contact the examination committee.

(5) The module descriptions in appendix 1 provide information on the prerequisites, the contents and learning objectives, the modes of instruction, the workload, the different types of active participation, the various assessments that students must take during the program, information on participation requirements in the different modes of instruction, the standard duration, and how often courses are offered.

(6) Appendix 2 is a recommended standard plan for completing the master’s degree program.

## Section 8

## Modes of Instruction

(1) The following modes of instruction will be offered as part of the curriculum:

1. Lectures (V) convey an overview of the subject as a whole and its methodological and/or theoretical foundations, or knowledge of a specific subject area and its research questions. It is used to present general contexts and theoretical foundations. The main mode of instruction is a presentation prepared by the respective instructor.

2. Practice sessions (Ü) impart applicable knowledge on a clearly defined subject area and the skills of independently working on a task, presenting the results, and discussing the subject using critical thinking. The main modes of instruction and learning are based on practicing work methods, practical knowledge, and language skills. The instructor leads students in the various activities and supervises these.

3. Seminar (S) convey knowledge on a clearly defined subject area and teach students the skills of independently researching an issue, presenting the results, and discussing the subject using critical thinking. The main modes of instruction and learning are seminar discussions conducted with the aid of learning materials, preparatory reading of specialist literature and sources, assignments, and group work.

4. Computer-based seminar (PC-S) equip students with knowledge of a clearly defined subject area and the skills to independently work on a task, present the results, and discuss the subject using critical thinking in a classroom setting. The main mode of instruction is group work on the PC, with an introduction to the use of specialized software.

5. Learning workshops (LW) represent a learning environment where materials are used to promote practical and autonomous learning and learning through one's own experiences. The learning workshop can take the form of a laboratory, simulation facilities, or workshops for practicing specific skills, with the aim of imparting holistic insights into complex interrelationships. The main mode of instruction is the teaching of research methods and skills and their application to a variety of examples.

6. In Colloquia (Ko), students and teachers hold presentations on current research findings followed by a group discussion.

7. Practical seminars (PrS) provide an opportunity for students to apply studying and learning content and the working methods of a scientific discipline in the context of a practical project. The primary format is the supervised implementation of a practical project.

8. Action learning (AL) aims to promote action-oriented learning (individually or in small groups) through observation, exploration, and experimentation, closely guided by the instructor, while also reflecting on the learning process. It typically uses integrated approaches that require the direct integration of data from multiple observational methods, evaluating and using the data from a variety of different perspectives.

9. An external internship (eP) is a set period of time where practical activities in an organization, a work process, or an institution lead to a deepening of already existing knowledge or the acquisition of new knowledge and skills and the ability to apply these in practice.

(2) The modes of instruction as outlined in (1) above can be implemented through blended learning formats. Blended learning combines on-site education with digital, internet-based media (e-learning). In this context, certain educational activities can be offered through Freie Universität Berlin's central e-learning applications. Students can work on these activities individually or in groups. They can complete them on their own or with the guidance of an

instructor. Blended learning can be used both as part of the active learning phase (discussing educational materials, sharing solutions to assignments, vigorous communication between instructors and students) and for follow-up activities (evaluating students' progress, applying and transferring knowledge).

## Section 9

## Master's Thesis

(1) The master's thesis is intended to demonstrate that a student has the ability to work independently on a research problem of their own choice from the area of planetary science and space exploration within a set timeframe using scientific methods, and can present, document, and analyze their findings (in writing and orally) in a form appropriate to the topic. Students must also be able to present and discuss their work orally.

(2) Students will be admitted to work on a master's thesis by submitting a request, provided that

1. they were most recently enrolled in a master's degree program at Freie Universität Berlin,
2. and they have successfully completed modules totaling at least 60 CP in the course of the master's degree program.

(3) The admission request for the master's thesis must be accompanied by proper documentation of the prerequisites listed under Section 9.1.2 above, as well as confirmation from an instructor who is an authorized examiner that they are willing and able to act as supervisor for the master's thesis. The relevant examination committee is responsible for approving requests. If the request does not include confirmation from an instructor as described above, the examination committee will appoint the student a supervisor. The function of supervision is to guide students toward an understanding of and compliance with the rules of good scientific practice in the context of the specific requirements of the student's subject area. Students have the opportunity to propose topics for their thesis; however, there is no guarantee that their proposed topics will be approved.

(4) The examination committee in coordination with the thesis supervisor assign the topic of the master's thesis. The topic and assignment must be designed in such a way as to ensure the work can be completed before the deadline. The assignment and compliance with the submission deadline must be documented and kept on file.

(5) The period of 900 hours for working on the thesis begins with the date on which the examination committee assigns the topic. The student has 21 weeks to complete and submit the master's thesis.

(6) The topic can also be declined within the first three weeks of being assigned, in which case it will be deemed not issued.

(7) During the 900-hour period, the student should regularly discuss their progress with their supervisor. They will also present their work in progress in a colloquium in a relevant area, where the supervisor will assist them in reflecting on their work to date, using current scientific ideas in the field to help the student develop ideas and thoughts on their topic. Active participation in the colloquium is mandatory.

(8) The master's thesis should be about 20,000 words in length.

(9) Students must submit three bound printed copies of their master's thesis as well as an electronic copy in Portable Document Format (PDF) by the stipulated submission deadline. The PDF file must be machine-readable and not just an image of the printed version. Furthermore, it may not be subject to any rights restrictions. When the student submits their master's thesis, they must include a written statement confirming that they alone are responsible for the content of the thesis and that they only used the sources and resources cited in the thesis.

(10) The master's thesis is to be assessed by two authorized examiners appointed by the examination committee, one of whom must be the supervisor of the thesis. The grade for the master's thesis is calculated as the arithmetical mean of the grades awarded by the two examiners. The two grades should be submitted to the examination committee within eight weeks after the submission of the thesis.

(11) The findings of the master's thesis will be presented and discussed orally. The date of the presentation will be communicated to the student in good time.

(12) The presentation should last around 40 minutes, comprising a talk by the student on the findings of the thesis (about 20 minutes) and a subsequent discussion (about 20 minutes).

(13) The presentation will be assessed by the two authorized examiners who graded the master's thesis. The grade for the presentation is calculated as the arithmetical mean of the two grades awarded by the two examiners.

(14) The grade awarded for the written master's thesis contributes as a proportion of five-sixths of the cumulative grade for the master's thesis, with the grade for the oral presentation contributing one-sixth.

(15) The master's thesis is considered passed if the overall grade awarded is "sufficient" (4.0) or higher.

(16) A student's work on a master's thesis elsewhere can be recognized/transferred to Freie Universität. The recognition request should be submitted to the examination committee. In order for such work to be recognized for the master's thesis, the examination conditions and the assignment of the submitted work must not differ substantially in terms of quality, level, learning outcomes, scope, and profile when compared to the examination conditions and the assignment of a master's thesis completed in this master's program, which particularly demonstrates the type of professional qualification this master's degree program provides.

## Section 10

## Electronic (Online) Examinations

(1) Where examinations take place online, the examination and grading for the examination will take place using digital technologies.

(2) The suitability of the chosen technologies for the purpose of carrying out the examination and completing the examination questions must be approved in advance by two examiners.

(3) The identity of the candidate taking part in the exam and the validity of the examination results must be verified. For this purpose, the examination results must be unambiguously identifiable and permanently assignable to the correct student in the digital system. It must be ensured that the electronic data are unchanged and complete for the purposes of grading and verifying the results.

(4) If an examination has been graded automatically via digital means, the student may request that an examiner verifies the result.

## Section 11

## Multiple-Choice Questions

(1) Examination “multiple-choice” questions must be set by two examiners.

(2) If it becomes clear during the grading of multiple-choice questions that there is a conspicuous pattern of errors in relation to certain questions, the two examiners must review the questions again to establish whether they sufficiently reflect the qualification objectives of the relevant module and their usefulness for the purpose of obtaining reliable examination results. If, as a result of the review, the questions are deemed not to meet these criteria, they will not be factored into the examination result. The number of questions to be graded to obtain the examination result shall be reduced accordingly. Such a reduction in the number of questions must not disadvantage the examination candidate. Should the proportion of points that would have been awarded for the eliminated questions form 15% or more of the maximum possible points in the multiple-choice section, one of the examiners must immediately forward all the examination documents to the examination committee before the examination results are released. The examination committee will then decide whether the entire examination must be repeated, or whether it can still be graded without factoring in the questions eliminated through the process described above.

(3) An examination in the form of multiple-choice questions is deemed passed where the candidate has achieved at least 50% of the possible maximum points (absolute passing grade), or if the number of points achieved by the student does not fall more than 10% below the average number of points achieved by all candidates who participated in the examination (relative passing grade). If the relative passing grade is used, the candidate must still achieve at least 40% of the total possible points in order to pass the examination.

(4) Multiple-choice examinations must be graded as described below.

Where the candidate has achieved the minimum number of points as defined under Section 11.3 above, they will be graded according to the following criteria:

- “very good” for a number of points that totals at least 75% more than the required minimum number of points under Section 11.3;
- “good” for a number of points that totals at least 50%, but less than 75%, more than the required minimum number of points under Section 11.3;
- “satisfactory” for a number of points that totals at least 25%, but less than 50%, more than the required minimum number of points under Section 11.3;
- “sufficient” for a number of points up to 25% more than the required minimum number of points under Section 11.3. For the grading system, please also refer to the framework regulations for degree programs and examinations (RSPO).

(5) The grading requirements stipulated above will not be applied where 1. the examiners who set the questions as described in Section 11.1 are also the examiners responsible for grading the multiple-choice answers, or 2. the proportion of maximum points achievable in the multiple-choice section makes up no more than 25% of the examination as a whole where the examination is only partly in multiple-choice format.

## Section 12

## Retaking Exams and Assessments

(1) If a student does not pass their master's thesis, they can attempt the assessment two more times. For all other exams and assessments in the program, they can retake them three more times.

(2) Exams and assessments that receive a grade of "sufficient" (4.0) or better cannot be retaken.

## Section 13

## Study Abroad

(1) Students are encouraged to study abroad. Courses of study that can be accredited within the master's degree program must be completed while studying abroad.

(2) The study abroad period must be preceded by a learning agreement between the student, the head of the examination committee, and the responsible point of contact at the host university. The agreement covers the length of the study abroad period, the courses of study to be completed while studying abroad, which must equate to the courses of the master's degree program, and the credit points allocated to the completed courses of study. Coursework completed in accordance with this agreement will be recognized.

(3) The Institute for Geological Sciences of Freie Universität Berlin supports students in planning and preparing for a period of study abroad.

(4) The third semester in the program lends itself well to study abroad, and students are encouraged to study abroad then.

## Section 14

## Degree Completion

(1) In order to graduate, students must complete the coursework and assessments outlined in sections 7 and 9.

(2) A student is not eligible for graduation if they have definitively failed some coursework or assessment or are involved in a pending examination procedure at another university in the same course of study or in a module that is identical or comparable to one of the modules to be completed in the master's degree program here and that will be taken into account when determining their overall grade.

(3) The application request for the award of a degree must be accompanied by documentation showing the student has completed the requirements mentioned in Section 14.1 as well as a guarantee that the applicant is not subject to any of the eligibility restrictions mentioned in Section 14.2. The relevant examination committee is responsible for approving the application.

(3) Upon successful completion of the assessment, the student will receive a Master of Science (MSc) university degree. Students receive a degree certificate and a diploma (appendixes 3 and 4), in addition to a diploma supplement (English and German versions). In addition, a degree certificate supplement with details of the individual modules and their components (transcript) is prepared. Additional English versions of the transcript and degree certificate may be issued upon request.

## Section 15

## Entry into Force

These regulations enter into force on the day following their publication in *FU-Mitteilungen* (the official bulletin of Freie Universität Berlin).

**Appendix 1: Module Descriptions**

Explanations:
The following module descriptions designate, unless referred to other regulations, for each module of the Master's program.
- the name of the module,
- the person responsible for the module,
- the prerequisites for access to the respective module,
- contents and qualification objectives of the module,
- teaching and learning forms of the module,
- the student workload estimated for the successful completion of a module,
- forms of active participation,
- the forms of examination,
- the obligation for regular participation,
- the credit points assigned to the modules,
- the standard duration of the module,
- the frequency of offering,
- the usability of the module.

The information on the time required takes into account in particular
- the active participation within the framework of the attendance study time,
- the working time required for the completion of smaller tasks within the scope of the attendance study time,
- the time for independent preparation and follow-up,
- the processing of study units in the online study phases,
- the immediate preparation time for examination performances,
- the examination time itself.

The time specifications for self-study (including preparation and follow-up work, exam preparation) represent guideline values and are intended to provide students with assistance in organizing their module-related workload in terms of time. The information on the workload corresponds to the number of credit points assigned to the respective module as a unit of measurement for the student workload that must be performed for the successful completion of the module. One credit point corresponds to 30 hours.
Insofar as the obligation to participate regularly is stipulated for the respective forms of teaching and learning, it is a prerequisite for the acquisition of the credit points assigned to the respective module, in addition to active participation in the forms of teaching and learning and the successful completion of the examinations of a module. Regular participation is deemed to have taken place if at least 80% of the attendance study time provided for in the teaching and learning forms of a module has been attended. If there is no obligation to regularly attend a teaching and learning form of a module, it is nevertheless strongly recommended. The determination of an attendance obligation by the respective instructor is excluded for forms of teaching and learning for which attendance is merely recommended in the following. In modules in which alternative forms of active participation are provided for, the forms of active participation to be determined according to the student's workload for the respective semester are to be determined by the responsible teacher at the latest in the first course meeting.
For each module - if provided for - the corresponding module examination must be taken. Assessed modules are completed with only one examination (module examination). The module examination is to be related to the qualification objectives of the module and examines the achievement of the objectives of the module in an exemplary manner. The scope of the examination shall be limited to what is necessary for this purpose. In modules in which alternative forms of examination are provided for, the form of examination for the respective semester is to be determined by the responsible teacher in the first course meeting at the latest.
The active and - if provided for - regular participation in the teaching and learning forms as well as the successful completion of the examination performances of a module are prerequisites for the acquisition of the credit points assigned to the respective module. In the case of modules without module examinations, active and regular participation in the teaching and learning forms is a prerequisite for the acquisition of the credit points assigned to the respective module.

## 1. Synchronization area

| | | | | |
|---|---|---|---|---|
| **Module:** Geological foundations | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students have a basic understanding of the structure, evolution and dynamics of terrestrial planets from the perspective of the Earth. Based on the knowledge of the most important physical and chemical processes, they understand the fundamental cycles of the Earth system also in comparison to other planetary bodies. They are able to identify the most important rock-forming minerals and rocks and can assign them to formation conditions. Students know the main principles of the structure and properties of rock-forming minerals. They can successfully work on tasks in teams and present the results appropriately. | | | | |
| **Contents:** Students learn about the fundamental systems and processes of planet Earth. This includes, among other things, the dimensions of space and time, the chemical composition, the geoscientific cycles, such as sedimentary cycles, as well as the interaction between hydrosphere, atmosphere and geosphere. They also address magmatism, metamorphism and rock deformation, as well as plate tectonics. With the help of macroscopy and microscopy, minerals and rocks are determined and results are presented and discussed in groups. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Action-Learning | 2 | Exercises, group work, determination of rocks and minerals | Attendance time AL<br>Pre- and postprocessing AL<br>Exam preparation and examination | 30<br>50<br>40 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance.<br><br>The module examination is not graded differentially. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, Action-Learning: yes | | |
| **Total workload** | | 180 hours | | 6 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Computational methods | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have the basic knowledge to describe and solve physical problems numerically. They can independently develop and apply numerical algorithms for practical application examples in several programming languages. They can statistically process and interpret measurement data with the help of numerical models. They will be able to argue for the interpretations and, if necessary, develop them further in teams. | | | | |
| **Contents:** The students deal with the common programming languages in the geosciences and their application areas. They learn the basics of programming in modern development environments and receive an introduction to numerical methods for solving geoscientific problems as well as an overview of the finite difference method using planetary application examples. They will become acquainted with various visualization examples from planetary sciences and remote sensing. They will learn the basics of probability theory and statistics. Using practical examples from planetary sciences, they will apply and interpret statistical methods for data analysis in a statistical programming environment. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 1 | | Attendance time L<br>Pre- and postprocessing L | 15<br>20 |

| | | | | |
|---|---|---|---|---|
| Computer-based seminar | 3 | Exercises | Attendance time PC-S<br>Pre- and postprocessing PC-S<br><br>Exam preparation and examination | 45<br>60<br><br>40 |
| **Module Exam** | | Programming exercise (approx. 200 lines) and presentation (approx. 20 minutes).<br><br>The module examination is not graded differentiated. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, computer-based seminar: yes | | |
| **Total workload** | | 180 hours | | 6 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| **Module:** Physical and mathematical foundations | | | | |
|---|---|---|---|---|
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have basic knowledge of mathematical and physical tools in planetary sciences and remote sensing, in particular the technical ability to independently describe and solve or handle physical processes and data mathematically. They can apply mathematical and physical principles to specific planetary physics problems and successfully process them. | | | | |
| **Contents:** The students deal with mathematical and physical methods in potential theory and apply them to gravitational fields and magnetic fields. They also learn the basics of fluid dynamics, thermodynamics and radiation physics. In exercises they deal with typical problems in planetary sciences and remote sensing and apply the physical and mathematical basics to problems related to their studies. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L<br><br>Attendance time P | 30<br>30<br><br>30 |
| Practice session | 2 | Exercises | Pre- and postprocessing P<br><br>Exam preparation and examination | 50<br><br>40 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance.<br><br>The module examination is not graded differentially. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 180 hours | | 6 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

## 2. Core area

| | | | | |
|---|---|---|---|---|
| **Module:** Introduction to planetary sciences and planet formation | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students have basic knowledge of celestial mechanics and stellar astronomy; they have an overview of the structure of the solar system, and they know planetary processes. They understand the basic processes that lead to the formation of planets in our solar system and can transfer their knowledge to extrasolar planetary systems and argue for them. They have an overview of the use of space probes in planetary research, can assess their usefulness for research, and understand and consider the views and interests of others in discussions. | | | | |
| **Contents:** The students learn the astronomical and celestial mechanics basics. Among other things, they deal with the formation, functioning, and classification of stars. They learn about the chemical and physical processes within the formation of our solar system with all its bodies and the ongoing planetary processes and learn to transfer their knowledge to other planetary systems and to argue for them. They will get an overview of space missions in planetary science. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 3 | - | Attendance time L<br>Pre- and postprocessing L | 45<br>45 |
| Seminar | 2 | Presentation or short written paper on a topic; active participation in discussions | Attendance time S<br>Pre- and postprocessing S | 30<br>60 |
| Practice session | 1 | Exercises | Attendance time P<br>Pre- and postprocessing P | 15<br>30 |
| | | | Exam preparation and examination | 45 |
| **Module Exam** | | Written examination (120 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, seminar and practice session: yes | | |
| **Total workload** | | 270 hours | | 9 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Principles of GIS and remote sensing | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geographical sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have basic knowledge of the characteristics and processing of geodata in general and of the physical principles of remote sensing in particular. The knowledge includes common geodata models, the acquisition of geodata and the basics of geographic data processing, as well as the properties of electromagnetic radiation and its interaction with matter and particles. The students are familiar with the physical and technical principles of different sensor systems and their possible applications and know the interfaces to other sub-disciplines. They can apply their knowledge strategically to concrete problems with the help of suitable software and to present their results appropriately. | | | | |
| **Contents:** Students deal with the basics of geodata models and methods of processing with a content focus on remote sensing data. This includes a general introduction to cartographic basics and geodata models (projections, vector, raster), to methods of geodata acquisition (digitisation, remote sensing) and to geodata processing (radiometric calibration, geometric rectification, ratio formation). In addition, they deal with the physical fundamentals of electromagnetic radiation and its interaction with matter and particles, which form the basis for remote sensing-based sensors. These basics are deepened using real conditions of planets, especially the Earth. The contents include electromagnetic radiation in free space (electromagnetic waves, polarisation, Doppler effect; thermal radiation); interaction of radiation with the atmosphere (scattering by particles of different sizes, radiation transfer equation) and solid matter (absorption and reflection at rough surfaces); overview of important remote sensing sensors for observing surfaces and atmospheres. In practical exercises, the fundamentals learned are applied to concrete problems using common software packages for remote sensing and GIS, and the results and solutions are discussed in the group. | | | | |

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Computer-based seminar | 1 | Exercises | Attendance time PS-S<br>Pre- and postprocessing PC-S<br>Exam preparation and examination | 15<br>60<br>45 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance, or oral examination (approx. 15 minutes) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, computer-based seminar: yes | | |
| **Total workload** | | 180 hours | | 6 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| **Module:** Planetary physics | |
|---|---|
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | |
| **Responsible for the module:** lecturer of the module | |
| **Access requirements:** none | |
| **Qualification objectives:** The students have basic knowledge about structure and composition of planets on the basis of geophysical observations and thermodynamic models. They have the ability to apply what they have learned confidently and independently and can transfer their knowledge to new problems and, if applicable, develop it further in teams. They can lead groups responsibly within the framework of complex tasks and present and discuss results. | |
| **Contents:** Students learn the basic physical differences of planetary bodies and methods for determining their mass and size. They deal with the shapes of planetary bodies, their measurement, and the mathematical description and analysis of their surrounding fields and processes at the surface. They deal with the figure and internal structure of planets and the associated geophysical and thermodynamic processes. They learn to work responsibly in groups on tasks and to present and discuss them appropriately. | |

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>40 |
| Practice session | 2 | Exercises, group work | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>40<br>40 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 180 hours | | 6 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| **Module:** Planetary atmospheres and climate | |
|---|---|
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Meteorology | |
| **Responsible for the module:** lecturer of the module | |
| **Access requirements:** none | |
| **Qualification objectives:** The students are familiar with the structure of planetary atmospheres. They have basic knowledge for working out and interpreting radiation and energy balances. They are familiar with the basics of | |

thermodynamics and hydrodynamics of planetary atmospheres and have the methodological skills for their application. They can apply their knowledge of atmospheric processes to different planetary climate states and argue their findings in the group.

**Contents:** The students deal with the structure and properties of planetary atmospheres using examples inside and outside the solar system. They learn methods for calculating the radiation and energy balance as well as the basics of radiative transfer in planetary atmospheres, and they deal with the fundamentals of atmospheric thermodynamics and hydrodynamics. They learn to explain and discuss the dependence of planetary climate states on planetary configuration and atmospheric properties.

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>40 |
| Practice session | 2 | Exercises | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>40<br>40 |

| | | |
|---|---|---|
| **Module Exam** | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | |
| **Module language** | English | |
| **Obligation to attend regularly** | Lecture: attendance is recommended, practice session: yes | |
| **Total workload** | 180 hours | 6 CP |
| **Module duration** | one semester | |
| **Frequency of offer** | every summer semester | |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration | |

**Module:** Insights into current research

**University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences

**Responsible for the module:** lecturer of the module

**Access requirements:** none

**Qualification objectives:** Students are familiar with representative current research topics in planetary sciences and Space exploration. They are familiar with the principles of good scientific practice and can question approaches and results of scientifically complex topics through sensibly formulated criticism and lead overarching discussions in technically and culturally diversely composed groups. They have an insight into the working methods and objectives of scientific working groups at various institutes and research facilities. They are able to independently acquire and present content and thus promote the development of others.

**Contents:** Students gain insight into the research results of current topics in planetology and space exploration through lectures by national and international scientists. In addition, new scientific findings from the ongoing work of the various disciplines are presented and discussed, and changing current topics are discussed via literature study. The students gain a representative insight into the diversity of scientific topics and follow the scientific process from hypothesis to publication using examples of topics from everyday research. They gain direct experience of the daily process of research in developing fields of work.

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Colloquium I | 2 | Presentation | Attendance time C I<br>Pre- and postprocessing C I | 30<br>60 |
| Colloquium II | 2 | Presentation | Attendance time C II<br>Pre- and postprocessing C II | 30<br>60 |

| | | |
|---|---|---|
| **Module Exam** | None | |
| **Module language** | English | |
| **Obligation to attend regularly** | yes | |
| **Total workload** | 180 hours | 6 CP |
| **Module duration** | two semesters | |
| **Frequency of offer** | every winter and summer semester | |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration | |

**Module:** Insight into the professional and research landscape

| | | | | |
|---|---|---|---|---|
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students will have practical experience of working in a university or non-university research institution or company in Germany or abroad and will be able to compare and discuss these experiences with the working methods and thematic focuses of various other research institutions and companies. | | | | |
| **Contents:** During the external internship, the students gain a practical insight into the structure and working methods of a university or non-university research institution or company in Germany or abroad. The students present in the group the different possibilities of professional practice in planetary research or space exploration with their requirements and challenges. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| External subject-related internship | 260 hours | | Attendance time exl<br>Attendance time S<br>Pre- and postprocessing S | 260<br>15<br>15 |
| Seminar | 1 | Presentation | Exam preparation and examination | 10 |
| **Module Exam** | | Internship report (approx. 1000 words); module exam is not differentially graded. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | yes | | |
| **Total workload** | | 300 hours | | 10 CP |
| **Module duration** | | two semesters; subject-related internship during the lecture-free period, seminar in the winter semester | | |
| **Frequency of offer** | | start every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

## 3. Specialization area

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|---|---|---|---|---|
| **Module:** Planetary exploration: space missions | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students have knowledge of the history of planetary missions, their design, and their technological background. They can discuss scientific goals, data bases and specific scientific results of missions. They have insights into the framework of spaceflight and are able to independently formulate scientific goals for space missions. They are able to work on tasks independently and to present the results appropriately in written and spoken form. | | | | |
| **Contents:** Students will learn about different space missions to the objects of our solar system with their goals, results and resulting findings by means of examples. They will learn the basics of space mechanics and discuss mission profiles with which objects in the solar system are explored in terms of technology, navigation, propulsion technology and scientific requirements. Using concrete examples, they learn to develop their own goals while taking into account the framework conditions for space missions. To this end, teamwork is also carried out to define a specific space mission, starting with the definition of the mission objectives, the technical requirements and the operational implementation. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>20 |
| Practice session | 2 | Exercises, presentation, team work | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>40 |
| **Module Exam** | | Term paper (approx. 2,500 words) or poster with presentation (approx. 20 minutes) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Planetary exploration: methods and instrumentation | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students know space instruments and their performance, as well as scientific techniques and measurement strategies as well as methods for the evaluation of instrument data used in planetary research. They are able to formulate measurement strategies and instrument proposals as well as scientific evaluation methods in a goal-oriented manner, to present them orally and in writing, and to argue for them. | | | | |
| **Contents:** Students are taught specific measurement methods and the instrumentation required. Students will study various remote sensing techniques from space probes covering a wide range of wavelengths, as well as instrumentation from orbit and in situ, while focusing on the geological, geophysical, and geochemical research questions and their remote measurement approaches. Typical planetary object exploration techniques and sample return techniques will be presented and discussed. Specific examples are used to develop own measurement strategies and to select suitable instruments. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>20 |
| Practice session | 2 | Exercises, presentation | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>40 |
| **Module Exam** | | Term paper (approx. 2,500 words) or poster with presentation (approx.20 minutes) | | |

| | | |
|---|---|---|
| **Module language** | English | |
| **Obligation to attend regularly** | Lecture: attendance is recommended, practice session: yes | |
| **Total workload** | 150 hours | 5 CP |
| **Module duration** | one semester | |
| **Frequency of offer** | every winter semester | |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration | |

| | |
|---|---|
| **Module:** Planetary surface processes and morphology | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | |
| **Responsible for the module:** lecturer of the module | |
| **Access requirements:** none | |
| **Qualification objectives:** The students have knowledge of geological and geomorphological processes. They can quantitatively analyze the morphology or properties of planetary surfaces using various methods and classify the results in the context of the evolutionary history of the respective body. They can interpret surface morphology and composition in comparison to other bodies and know which physical parameters or object-specific environmental conditions influence surface processes. They are able to represent the interpretations argumentatively and, if applicable, to develop them further in teams and to present the results appropriately. | |
| **Contents:** Students learn important surface properties such as albedo, composition, roughness, mechanical properties, topography and get an overview of planetary surface forms, important morphological similarities and differences of different planetary surfaces. Basic knowledge of relevant and object-specific physical/geological processes on solid surfaces of planetary bodies will be provided, as well as knowledge of important circulation processes and factors affecting surface processes. Students gain an overview of chronology of surface processes. They learn to apply their knowledge to different problems and to work on them in groups. | |

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Seminar | 2 | Presentation, group work | Attendance time S<br>Pre- and postprocessing S<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance, or oral examination (approx. 30 minutes) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, seminar: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | |
|---|---|
| **Module:** Advanced Remote Sensing of the Earth | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geographical sciences | |
| **Responsible for the module:** lecturer of the module | |
| **Access requirements:** Successful completion of the module "Principles of GIS and remote sensing". | |
| **Qualification objectives:** Students are able to independently apply Earth observation and geoinformation methods and access current research questions and literature as well as systematically address problems within a larger context. They are able to prepare the most important necessary approaches and methods for advanced geodata analysis and to evaluate Earth observation data and critically assess results. They can develop scientific research questions in the fields of remote sensing and geoinformation independently and in the group and implement them independently with the help of the acquired knowledge of an applied programming language as well as present the results professionally. | |
| **Contents:** The concepts, methods and algorithms indispensable for the thematic processing of digital image data are presented, as well as principles and advanced procedures of pattern recognition and information extraction, methods of data fusion, further remote sensing systems such as hyperspectral and radar and procedures for the spatio-temporal analysis of geodata. The theoretical contents of the lecture will be deepened and practiced in the seminar with the help of common software packages and applied programming languages. This includes programming exercises on quantitative analyses of geo and environmental data, e.g. the regular and independent execution of exercises in R and Matlab and their short presentation as well as the conception and execution of a final project. | |

| Forms of teaching and learning | Classroom study (Semester hours per week) | Forms of active participation | Workload (hours) | |
|---|---|---|---|---|
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Computer-based seminar | 3 | Exercise, presentation | Attendance time PC-S<br>Pre- and postprocessing PC-S<br>Exam preparation and examination | 45<br>150<br>45 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance or term paper (approx. 3,000 words) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, computer-based seminar: yes | | |
| **Total workload** | | 300 hours | | 10 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

**Module:** Introduction to advanced geodata analysis

**University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geographical Sciences

**Responsible for the module:** lecturer of the module

**Access requirements:** Successful completion of the module "Principles of GIS and remote sensing".

**Qualification objectives:** The students have advanced knowledge of current methods for the automated processing and analysis of remote sensing data. They can independently formulate current questions from the field of planetary sciences and work on them in a group with the help of subject-specific software and an applied programming language and present the results in a professional manner.

**Contents:** The students learn current procedures from the field of geodata processing. These include, for example, procedures for deriving and processing specific parameters (e.g. by analysing multispectral and hyperspectral data and their intersection). This also includes methods for Big Data processing and possible applications as well as an introduction to various machine learning approaches, including their theoretical foundations, practical application as well as evaluation of various algorithms (e.g. Random Forest, Support Vector Machines, Neural Networks).
The contents of the module are derived in group work based on a specific problem. The students prepare the theoretical basics in presentations. With the help of common software packages and applied programming languages, these methods are practically implemented and learned. Students discuss concepts and progress of the group projects, incl. short presentations.

| Forms of teaching and learning | Classroom study (Semester hours per week) | Forms of active participation | Workload (hours) | |
|---|---|---|---|---|
| Computer-based seminar | 3 | Short presentations, final project | Attendance time PC-S<br>Pre- and postprocessing PC-S<br>Exam preparation and examination | 45<br>45<br>60 |
| **Module Exam** | | Presentation of final project (approx. 45 minutes) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Computer-based seminar: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

**Module:** Celestial mechanics

**University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences

**Responsible for the module:** lecturer of the module

**Access requirements:** none

**Qualification objectives:** Students have basic knowledge of the derivation of Kepler's laws from Newton's axioms and Newton's law of gravitation, the properties and classification of types of motion, and the confirmation of Kepler's solutions

to the two-body problem by observations of the motion of bodies in the solar system. Students have basic knowledge of the physical derivation and properties of the gravitational three-body problem. They can independently transfer and apply their knowledge to selected problems and develop strategies for solving them.

**Contents:** The students deal with the development of the world view from Ptolemy via Copernicus to Kepler and the Kepler laws as empirical findings. The exact derivation of Kepler's laws from Newton's equations is described, the conservation variables, as well as the classification of the types of motion and the orbital elements. Students deal with the derivation of the restricted circular three-body problem from the basic dynamical equations, the Jacobi integral, zero-velocity curves, and Lagrangian points. They use their knowledge to classify comets using selected examples. They work with simple perturbation calculations of the two-body problem.

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |

| | | |
|---|---|---|
| **Module Exam** | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | |
| **Module language** | English | |
| **Obligation to attend regularly** | Lecture: attendance is recommended, practice session: yes | |
| **Total workload** | 150 hours | 5 CP |
| **Module duration** | one semester | |
| **Frequency of offer** | every winter semester | |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration | |

**Module:** The outer solar system

**University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences

**Responsible for the module:** lecturer of the module

**Access requirements:** none

**Qualification objectives:** Students have basic knowledge of the evolution of the outer solar system, from Jupiter to the Oort Cloud, including the systems of the gas giants Jupiter and Saturn, as well as the ice giants Uranus and Neptune, dwarf planets such as Pluto, small bodies (e.g., comets), and the heliopause. They can describe the physical and dynamical properties of bodies and processes and know multidisciplinary techniques for studying the physical properties of these objects. They can successfully complete tasks in groups and present the results appropriately.

**Contents:** Students work out, sometimes in groups, the physical and dynamical properties of bodies and processes occurring in the outer solar system, from Jupiter to the Oort Cloud, and present their results. Systems in the outer solar system include the moons, some with active volcanism, cryovolcanism, and atmospheres, and the smaller bodies beyond Neptune, some of the most pristine objects known. A solid understanding of the current state of the outer solar system bodies, as well as their formation and evolution, is provided, and multidisciplinary techniques such as telescopic observations or in situ analyses used to study the broad range of physical properties of objects are taught.

| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
|---|---|---|---|---|
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises, presentation, group work | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |

| | | |
|---|---|---|
| **Module Exam** | Written examination (90 min), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | |
| **Module language** | English | |
| **Obligation to attend regularly** | Lecture: attendance is recommended, practice session: yes | |
| **Total workload** | 150 hours | 5 CP |
| **Module duration** | one semester | |
| **Frequency of offer** | every winter semester | |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration | |

| **Module:** Magnetospheres | | | | |
|---|---|---|---|---|
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have basic knowledge about the formation of magnetospheres by the interaction of the solar wind and the interplanetary magnetic field with the magnetic fields of the planets. They can name and explain the physical basis of the structure and dynamics of magnetospheres and describe the differences of magnetospheres in the solar system. Students will be able to independently apply basic methods to describe plasmas in space. | | | | |
| **Contents:** Students will study the solar wind and the interplanetary magnetic field and the resulting formation of different magnetospheres in the solar system. The formation of magnetospheres and their structure, the formation of tail and cusp, plasma and currents in the magnetosphere are addressed. Furthermore, students deal with reconnection, the coupling of the terrestrial magnetosphere with the ionosphere and its dynamics, and the physics of induced magnetospheres. They learn methods for the description of plasmas and apply them. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| **Module:** Satellite-based meteorology | | | | |
|---|---|---|---|---|
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Meteorology | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** Successful completion of the module "Planetary atmospheres and climate". | | | | |
| **Qualification objectives:** The students possess basic knowledge of the current state of satellite-based remote sensing of the Earth in meteorology. They know the physical basics of the measurement methods and the mathematical basics of the inversion methods and can independently interpret and evaluate the diverse measurements and measurement methods and present the results. They receive an introduction to current data formats and programming development environments. | | | | |
| **Contents:** Students learn the basics of radiative transfer theory, with a focus on aspects important to remote sensing such as absorption, emission, and scattering of solar and terrestrial radiation by atmospheric components. They learn about various inversion methods such as lookup tables, linear and nonlinear regressions, PCA, neural networks, optimal estimation, and get an overview of current meteorological satellite-based remote sensing tools and methods. They apply the learned knowledge to current satellite data and discuss the results. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>45 |
| Practice session | 3 | Exercises, analysis of satellite data, interactive work with satellite data, creation of higher-quality satellite products | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 45<br>80<br>100 |
| **Module Exam** | | Term paper (approx. 3 000 words) | | |
| **Module language** | | English | | |

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|---|---|---|
| **Obligation to attend regularly** | Lecture: attendance is recommended, practice session: yes | |
| **Total workload** | 300 hours | 10 CP |
| **Module duration** | one semester | |
| **Frequency of offer** | every winter semester | |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration | |

| | | | | |
|---|---|---|---|---|
| **Module:** Planetary evolution and habitability | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students are familiar with the formation and thermo-chemical evolution of planetary bodies in the solar system. They have knowledge of the origin and development of life on Earth and its habitats and are able to assess in which extraterrestrial locations life could form and develop. They can assess what observations and experiments are needed to detect extraterrestrial life or habitable places beyond Earth. They can successfully complete tasks in teams and present the results appropriately. | | | | |
| **Contents:** Students will gain an overview of the formation and evolution of planets and moons and the framework for life in the universe. They discuss the definition of life and habitability and learn to assess the habitability of a planetary body. They address the origin of life on Earth, the conditions for the evolution of complex organisms, and the evolutionary history of life on Earth and its influence on the environment. They learn methods for detecting extraterrestrial life such as extremophile organisms, biomarkers, and biosignatures. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Group work, exercises, presentation | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written exam (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or a term paper (approx. 3000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Exoplanets | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have basic knowledge of the state of the art of research on extrasolar planets as well as the methods applied in the field of research. They can classify the solar system as one planetary system among many and apply their knowledge of planetology to exoplanets that cover an extended and diverse range of parameters and do not occur in the solar system. They know methods from different research areas of observational astronomy, Earth sciences, physics, and astrobiology and can apply them interdisciplinary in interdisciplinary groups. | | | | |
| **Contents:** Students will get an overview of planet types, populations and their characteristics. They will learn planetary system architectures and methods for planet detection with ground-based and satellite-based telescopes. They look at methods for determining the mass, radius, orbit, orbital inclination, and Love numbers of exoplanets of the relationship of the parameters to each other. Methods for determining the chemical composition of atmospheres are taught and an overview of previous data of extrasolar planetary atmospheres is given. In addition, students will be given an overview of habitability of extrasolar planets and the various methods used to detect biosignatures to detect life outside the solar system. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |

| | | | | |
|---|---|---|---|---|
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises,<br>group work | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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|---|---|---|---|---|
| **Module:** Geophysical modelling of planets and moons | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students are familiar with basic skills in the execution and development of numerical models, which are needed in practical applications in geophysics and planetology. They are able to derive various internal structures of planetary bodies based on their knowledge of the inner solar system. They understand the physical equations for the thermal evolution of a planetary body and are able to implement them using parameterized, one-dimensional models. Using two-dimensional numerical codes, they are able to model the convection of the rock mantle and assess its influence on the evolution of planetary bodies and discuss the results in a scientifically sound manner. | | | | |
| **Contents:** Students learn the elementary physical equations for heat transport by convection and conduction, the rheology of the mantle, the material properties of the and the interior structure models for various planets and moons. In exercises they deal complementarily with the basics of numerical modeling. In addition, they will apply mathematical and physical principles, develop simple 1D conduction models, derive material properties for various Earth minerals, run and fit an internal structure model for Earth-like planets, and run convection codes. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>15 |
| Computer-based seminar | 2 | Exercises | Attendance time PC-S<br>Pre- and postprocessing PC-S<br>Exam preparation and examination | 30<br>45<br>30 |
| **Module Exam** | | Written exam with practical application part (90 minutes) or term paper (approx. 3000 words) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, computer-based seminar: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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|---|---|
| **Module:** Numerical methods in geosciences and planetary sciences | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | |
| **Responsible for the module:** lecturer of the module | |
| **Access requirements:** none | |
| **Qualification objectives:** The students have basic knowledge for solving complex physical problems with the help of numerical methods. They possess the methodological skills for translating a physical problem into a numerical algorithm as well as the technical ability to independently solve complex problems in Earth and planetary sciences using practical applications in a programming language and to present their results in a professional manner. | |

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|---|---|---|---|---|
| **Contents:** The students learn procedures for the numerical solution of typical problems in the geosciences, e.g. methods for finding zeros, for numerical differentiation and integration and for solving ordinary and partial differential equations. Typical problems in Earth and planetary sciences will be treated on the basis of exercises and solutions will be worked out and presented. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or as a term paper (approx. 3,500 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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|---|---|---|---|---|
| **Module:** Meteorites and the formation of terrestrial planets | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students have basic knowledge of the composition, origin and formation of meteorites. They can distinguish different types of meteorites based on petrological and geochemical characteristics. They understand how the composition of meteorites allows conclusions to be drawn about the early evolution of the solar system and the terrestrial planets. They are able to develop content on their own, present it orally and in writing. | | | | |
| **Contents:** The students get an overview of the basics of classification, composition, origin and formation of meteorites and the physical processes in and on meteorites. They learn methods for the petrographic characterization of meteorites as well as their age determination. They deal with the relevance of meteorites and other planetary materials for understanding the formation, chronology and evolution of our solar system and especially the terrestrial planets. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | | Attendance time L<br>Pre- and postprocessing L | 30<br>15 |
| Seminar | 1 | Seminar presentation or short seminar paper on a specific topic | Attendance time S<br>Pre- and postprocessing S | 15<br>30 |
| Practice session | 1 | Exercises | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 15<br>15<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, seminar and practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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| **Module:** Laboratory methods for the analysis of planetary materials | |

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| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students are able to develop suitable strategies for the investigation of the mineralogy, microstructure and chemical composition of planetary materials and to apply the analytical methods in a basic way. They are able to independently develop the work process for solving a specific problem and to justify it in a scientifically sound manner. They are able to work successfully on tasks in teams and to interpret and critically question results. | | | | |
| **Contents:** Students learn the basics of sample preparation with a focus on impactites, meteorites and planetary analog materials. They apply spectroscopic methods to practical examples and learn the basic theory and application of optical spectroscopy and mass spectrometric techniques. They learn basic techniques for the characterization of mineral dusts and the application of microanalytical methods using practical examples including scanning electron microscopy, electron beam microprobe and Raman spectroscopy As well as basic theory and application of non-destructive micro X-ray fluorescence analysis. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 1 | | Attendance time L<br>Pre- and postprocessing L | 15<br>15 |
| Learning workshop | 3 | Group work, protocol | Attendance time LW<br>Pre- and postprocessing LW<br>Exam preparation and examination | 45<br>45<br>30 |
| **Module Exam** | | Written exam (60 minutes), which, if applicable, may be conducted in whole or in part in the form of the answer-choice procedure and also in the form of an electronic examination performance. | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, learning workshop: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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|---|---|---|---|---|
| **Module:** Planetary field trips | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** Students will be able to recognize typical rocks and structures of impact craters and volcanoes, analyze them with suitable methods and interpret the formation process. They are able to argue the interpretations and, if applicable, develop them further in teams. | | | | |
| **Contents:** The students deal with the structure and stratigraphy of impact structures and analyze impact processes on the basis of field findings. They learn the basics of impact metamorphism and to distinguish impactites from similar rocks of geological processes (especially volcanism) with suitable methods in the field. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Practical seminar | 3 | Group work, protocol preparation | Attendance time PrS<br>Pre- and postprocessing PrS | 45<br>30 |
| Seminar | 1 | | Attendance time S<br>Pre- and postprocessing S<br>Exam preparation and examination | 15<br>30<br>30 |
| **Module Exam** | | Protocol (approx. 5,000 words) | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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|---|---|---|---|---|
| **Module:** Special topics of planetary sciences | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have in-depth knowledge of selected topics in planetary research. They possess the methodological skills to understand the subject matter as well as the technical ability to apply what they have learned confidently and independently to specific problems and to develop strategies for solving them in teams. | | | | |
| **Contents:** Current topics in planetary research with special consideration of ongoing research projects. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises, group work, presentation | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or oral examination (approx. 20 minutes) or term paper (approx. 4,000 words) or protocol (approx. 4,000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter and summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

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|---|---|---|---|---|
| **Module:** Special topics of space exploration | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have in-depth knowledge of selected topics in space exploration. They have the methodological skills to understand the subject matter as well as the technical ability to apply what they have learned confidently and independently to specific problems and to develop strategies for solving them in teams. | | | | |
| **Contents:** Current topics in space exploration with special consideration of ongoing research projects. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises, group work, presentation | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or oral examination (approx. 20 minutes) or term paper (approx. 4,000 words) or protocol (approx. 4,000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter and summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Special topics of exploration of asteroids and other small bodies | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have in-depth knowledge of selected topics of research on small bodies in the solar system (meteoroids, asteroids, comets, dwarf planets and other small bodies). They possess the methodological skills to understand the subject matter as well as the technical ability to apply what they have learned confidently and independently to specific problems and to develop strategies for solving them in teams. | | | | |
| **Contents:** Current topics in the field of asteroid, meteoroid, comet and dwarf planet research with special consideration of ongoing research projects. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L<br><br>Attendance time P<br>Pre- and postprocessing P<br><br>Exam preparation and examination | 30<br>30<br><br>30<br>30<br><br>30 |
| Practice session | 2 | Group work, presentation | | |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or oral examination (approx. 20 minutes) or term paper (approx. 4,000 words) or protocol (approx. 4,000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter and summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Special topics of geology | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geological sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have in-depth knowledge of selected topics in the geological sciences. They possess the methodological skills to understand the subject matter as well as the professional ability to apply what they have learned confidently and independently to specific problems and to develop strategies for solving them in teams. | | | | |
| **Contents:** Current topics in geology with special consideration of ongoing research projects. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L<br><br>Attendance time P<br>Pre- and postprocessing P<br><br>Exam preparation and examination | 30<br>30<br><br>30<br>30<br><br>30 |
| Practice session | 2 | Exercises, group work | | |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or oral examination (approx. 20 minutes) or term paper (approx. 4,000 words) or protocol (approx. 4,000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |

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|---|---|
| **Frequency of offer** | every winter and summer semester |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration |

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|---|---|---|---|---|
| **Module:** Special topics of atmospheric sciences | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Meteorology | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** Successful completion of the module “Planetary atmospheres and climate“. | | | | |
| **Qualification objectives:** The students have in-depth knowledge of selected topics in planetary atmospheric research. They possess the methodological skills to understand the subject matter, as well as the technical ability to apply what they have learned confidently and independently to specific problems and to develop strategies for solving them. | | | | |
| **Contents:** Current topics in the field of planetary atmospheric science with special reference to current issues in research. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises, presentation | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or oral examination (approx. 20 minutes) or term paper (approx. 4,000 words) or protocol (approx. 4,000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |
| **Frequency of offer** | | every winter and summer semester | | |
| **Usability** | | Master's degree program Planetary Sciences and Space Exploration | | |

| | | | | |
|---|---|---|---|---|
| **Module:** Special topics of remote sensing | | | | |
| **University/Department/Teaching Facility:** Freie Universität Berlin / Earth Sciences / Geographical sciences | | | | |
| **Responsible for the module:** lecturer of the module | | | | |
| **Access requirements:** none | | | | |
| **Qualification objectives:** The students have in-depth knowledge of selected topics in remote sensing. They have the methodological skills to understand the subject matter as well as the technical ability to apply what they have learned confidently and independently to specific problems and to develop strategies for solving them in teams. | | | | |
| **Contents:** Current topics in remote sensing with special consideration of ongoing research projects. | | | | |
| **Forms of teaching and learning** | **Classroom study** (Semester hours per week) | **Forms of active participation** | **Workload (hours)** | |
| Lecture | 2 | - | Attendance time L<br>Pre- and postprocessing L | 30<br>30 |
| Practice session | 2 | Exercises, group work | Attendance time P<br>Pre- and postprocessing P<br>Exam preparation and examination | 30<br>30<br>30 |
| **Module Exam** | | Written examination (90 minutes), which may be conducted in whole or in part, if applicable, in the form of the answer-choice method and also in the form of an electronic examination performance or oral examination (approx. 20 minutes) or term paper (approx. 4,000 words) or protocol (approx. 4,000 words). | | |
| **Module language** | | English | | |
| **Obligation to attend regularly** | | Lecture: attendance is recommended, practice session: yes | | |
| **Total workload** | | 150 hours | | 5 CP |
| **Module duration** | | one semester | | |

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|---|---|
| **Frequency of offer** | every winter and summer semester |
| **Usability** | Master's degree program Planetary Sciences and Space Exploration |

**Appendix 2:** Example curriculum plan

<table>
<tr><th>Semester</th><th>Synchronization area<br>12 CP</th><th colspan="4">Core area<br>43 CP</th><th>Specialization area<br>35 CP</th></tr>
<tr><td>1st semester of study<br>27 CP</td><td>Module:<br>Geological foundations<br>6 CP<br><br>and/or<br><br>Module:<br>Physical and mathematical foundations<br>6 CP<br><br>and/or<br><br>Module:<br>Computational methods<br>6 CP</td><td colspan="2">Module:<br>Introduction to planetary sciences and planet formation<br>9 CP</td><td colspan="2">Module:<br>Principles of GIS and remote sensing<br>6 CP</td><td></td></tr>
<tr><td>2nd semester of study<br>31 CP</td><td></td><td>Module:<br>Planetary physics<br>6 CP</td><td>Module:<br>Planetary atmospheres and climate<br>6 CP</td><td rowspan="2">Module:<br>Insights into current research<br>6 CP</td><td rowspan="2">Module:<br>Insights into the professional and research landscape<br>10 CP</td><td>Elective modules totaling 10 CP</td></tr>
<tr><td>3rd semester of study<br>32 CP</td><td></td><td></td><td></td><td>Elective modules totaling 25 CP</td></tr>
<tr><td>4th semester of study<br>30 CP</td><td colspan="6">Master’s thesis, including participation in a colloquium and oral presentation of the thesis findings<br>30 CP</td></tr>
</table>