



Sommersemester 26

Module Guide

for the study of

**Space Sciences and Technologies- Sensing,
Processing, Communication (M.Sc.)**

Masterstudiengang

valid in connection with the examination regulations MPO v. 10.06.2020

This module guide details the contents of the master's programme Space-ST and the course of studies.

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Program Scheme Master „Space Sciences and Technologies – Sensing, Processing, Communication” („Space-ST”)

Semester	Pflichtmodule (Compulsory Modules), insgesamt 57 CP			Master- arbeit (Master Thesis), 30 CP	Projekt (Project), 12 CP	Wahlpflichtbereich (Compulsory Elective Modules), 12 CP		Wahlbereich (Elective Modules), 9 CP	Σ 120 CP
						„Physics for Space Observation” (PSO) (Specialization), 12 CP	„Information Technolo- gies for Space“ (ITS) (Specialization), 12 CP		
1	Foundations (30 CP)								30
	AMMDA Applied Mathemati- cal Methods and Data Analysis, 6 CP	CTh1(a) Control Theory 1, 6 CP	SpEl(a) Space Electronics, 3 CP						
	SEM Science and Explo- ration Missions, 3 CP	AtPhy Atmospheric Physics, 6 CP	ComSp Communication Tech- nologies for Space, 6 CP						
2	Remote Sensing and Communication (27 CP)							Elective Courses, 9 CP siehe Anlage 2.4	30
	SAMS(a) Sensors and Measurement Systems, 6 CP		DIP Digital Image Processing, 3 CP						
	GNSS The Global Navigation Satellite System, 3 CP	LSpa1 Space Lab, Part 1, 3 CP	AtSp Atmospheric Spectroscopy, 3 CP						
3	CNSp Communication Net- works for Space, 3 CP	LSpa2 Space Lab, Part 2, 3 CP	GG Geodesy and Gravity, 3 CP		PMA, Pro- ject, 12 CP	AtCM1 Atmospheric Chemistry Modelling: Part 1, 3 CP			30
4				ThsSpa Module Master Thesis, 30 CP					30

CP = Credit Points

Index by areas of study

1) Foundations (30 CP)

The foundation modules are compulsory and cover 30 CP during semester 1.

01-PHY-MA-AMMDA: Applied Mathematical Methods and Data Analysis (6 CP).....	3
01-PHY-MA-AtPhy: Atmospheric Physics (6 CP).....	5
01-ET-MA-ComSp: Communication Technologies for Space (6 CP).....	7
01-ET-MA-CTh1(a): Control Theory 1 (6 CP).....	9
01-ET-MA-PrSpa: Project (12 CP).....	11
01-PHY-MA-SEM: Science and Exploration Missions (3 CP).....	14
01-ET-MA-SpEl(a): Space Electronics (3 CP).....	16

2) Remote Sensing and Communication (27 CP)

The modules in Remote Sensing and Communication are compulsory; they are recommended for semesters 2 and 3.

01-PHY-MA-AtSp: Atmospheric Spectroscopy (3 CP).....	18
01-ET-MA-CNSp: Communication Networks for Space (3 CP).....	20
01-PHY-MA-DIP: Digital Image Processing (3 CP).....	22
01-PHY-MA-GeoGra: Geodesy and Gravity (3 CP).....	24
01-PHY-MA-GNSS: The Global Navigation Satellite System (3 CP).....	26
01-PHY-MA-LSpa1: Space Lab Part 1 (3 CP).....	28
01-ET-MA-LSpa2: Space Lab Part 2 (3 CP).....	30
01-ET-MA-SAMS(a): Sensors and Measurement Systems (6 CP).....	32

3) Specialization Areas (12 CP)

Specialization Areas are:

- Physics for Space Observations (PSO) and
- Information Technologies for Space (ITS)

The choice of a specialization and the respective modules are compulsory.

a) Physics for Space Observation (12 CP)

These modules are compulsory if the specialization area of choice is Physics for Space Observation (PSO).

01-PHY-MA-RSOC: Remote Sensing of Ocean and Cryosphere (6 CP).....	34
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01-PHY-MA-CliS1: Climate System I (3 CP).....	36
01-PHY-MA-AtCM1: Atmospheric Chemistry Modelling: Part 1 (Theory) (3 CP).....	38

b) Information Technologies for Space (12 CP)

For Information Technologies for Space (ITS), students choose two out of the three listed options (12 CP).

01-ET-MA-RFC(a): RF Frontend Devices and Circuits (6 CP).....	40
01-ET-MA-BiM: BioMEMS (6 CP).....	42
01-ET-MA-DiTe(a): Digital Technology (6 CP).....	44

4) Electives Modules (9 CP)

Electives must be chosen from this list of modules.

01-PHY-MA-BGC: Biogeochemistry (3 CP).....	46
01-ET-MA-CCod(a): Channel Coding (3 CP).....	48
01-PHY-MA-CliM1: Climate Modelling: Part 1 (3 CP).....	50
01-PHY-MA-Dyn1: Dynamics I (6 CP).....	52
01-ET-MA-EngE: Engineering Ethics (3 CP).....	54
01-ET-MA-InS(a): Integrated Circuits (6 CP).....	56
01-ET-MA-ML: Machine Learning for Swarm Exploration (3 CP).....	58
01-PHY-MA-PCSS: Philosophy of Cosmology, Space and Space Travel (3 CP).....	60
01-PHY-MA-RingSp: Fascination Space (3 CP).....	62
01-PHY-MA-SpTel: Space Telescopes (3 CP).....	64
01-ET-MA-WCom(a): Wireless Communications (6 CP).....	66

5) Master Thesis (12 CP)

01-ET-MA-ThsSpa: Master Thesis (incl. Colloquium) (30 CP).....	68
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6) Additional Courses

01-PHY-MA-0 Space-ST: Additional courses master program Space-ST (0 CP).....	70
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Module 01-PHY-MA-AMMDA: Applied Mathematical Methods and Data Analysis

Applied Mathematical Methods and Data Analysis

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

No formal requirements.

Learning content:

The course lectures cover the theoretical and practical basis of the following subject areas:

PART A:

- Calculus I (Functions, theorems)
- Calculus II (Differentiations, applications of derivatives, approximations, errors)
- Calculus III (Integrations, applications of integrals)
- Calculus IV (Series, convergence, divergence)
- Differential equations I (ordinary first, second and higher-order differential equations - ODE)
- Differential equations II (partial differential equations - PDE)
- Exercises on all the above

PART B

- Introduction to Python (Installation, build-in functions, arrays, data loading, handling, visualizing)
- Hands – on examples (numerical approximations, differential equations)

References:

- Thomas Calculus 13th or 14th edition (Hass, Heil, Weir) Pearson
- Mathematical Methods in the Physical Sciences (Boas) Wiley

Learning outcomes / competencies / targeted competencies:

Introduction to essential and advanced mathematical methods (Part A) and applying these using the Python programming language. In the example classes (part B), students will learn how to apply the taught knowledge, both analytically and numerically. In order to facilitate the latter, students will learn the basics of the Python programming language and how to use Python to solve real-world problems from the course's topic areas.

Calculation of student workload:

56 h SWS / presence time / working hours

68 h Exam preparation

56 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Mihalis Vrekoussis

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:
WiSe 20/21 / -

Credit points / Workload:
6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: written exam (or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Applied Mathematical Methods and Data Analysis

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-PHY-MA-AtPhy: Atmospheric Physics

Atmospheric Physics

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

No formal requirements.

Learning content:

The origin of the solar system and the earth's atmosphere; the physical parameters, which determine the conditions in the atmosphere (e.g. temperature, pressure, and vorticity); the physical laws, which describe electromagnetic radiation; the interaction between electromagnetic radiation and matter (absorption, emission and scattering); atmospheric radiative transport; radiation balance, climate change; atmospheric thermodynamics and the hydrological cycle; aerosols and cloud physics; an introduction into atmospheric dynamics (kinematics, circulation etc.).

References:

- Houghton, J.T., The physics of atmospheres, Cambridge University Press, 1977, ISBN 0 521 29656 0.
- Wallace, John M. and Peter V. Hobbs, Atmospheric Science, An Introductory Survey, Academic Press, 2nd Edition 2005, ISBN 0-12-732951-x

Learning outcomes / competencies / targeted competencies:

An adequate understanding of the fundamentals of atmospheric physics.

This addresses

- a) gaining an understanding of the laws of physics, which determine the behaviour of the earth system, which comprises the sun, the atmosphere and earth surface
- b) learning the ability to apply the laws of physics to calculate parameters and forecast conditions in the atmosphere.

This knowledge is required for subsequent advanced courses in the M.Sc. program. These learning outcomes provide essential knowledge required for success in the following areas:

- a) research in the atmospheric, environmental and climate sciences, meteorology, earth observation and remote sensing from ground based ship, aircraft and space based instrumentation,
- b) employment in earth observation, meteorology, and education by industry, governmental and space agencies.

Calculation of student workload:

56 h SWS / presence time / working hours

56 h Preparation / follow-up work

68 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Hartmut Bösch

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 23/24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: written exam (or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Atmospheric Physics

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-ComSp: Communication Technologies for Space

Communication Technologies for Space

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

Basics in linear algebra, calculus, differential equations, fourier transformation and physics (basics in electromagnetic waves) are recommended.

Learning content:

- Introduction to communications: history of wireless communication and space communication
- Basic concepts and terminology in communications
- Recap of Fourier transformation
- Introduction to system theory (signals, linear time invariant systems, convolution, statistic process, etc.)
- Passband-Baseband transformation and receiver concepts
- Wireless channel basics (linear and non-linear distortions, noise, Nyquist, etc.)
- Analog modulation
- Basics in sampling theory and discrete systems and signals
- Digital modulation
- Introduction to channel coding

Learning outcomes / competencies / targeted competencies:

As outcome, the students should be able to:

- explain basic communications concepts and theoretical foundations;
- apply mathematical tools and concepts relevant in communications;
- explain and apply analog and digital modulation.

Calculation of student workload:

56 h Self-study

68 h Exam preparation

56 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Dr.-Ing. Carsten Bockelmann

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 20 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Gemäß MPO-Space-ST-02-24, PL:1

Module courses

Course: Communication Technologies for Space

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Teaching format(s):

Associated module examination:

Modulprüfung

Module 01-ET-MA-CTh1(a): Control Theory 1 / Regelungstheorie 1

Control Theory 1

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

Vorlesung Grundlagen der Regelungstechnik

Learning content:

- Definition und Eigenschaften von Zustandsvariablen / Definition and features of state variables
- Zustandsdarstellung linearer Systeme / State space description of linear systems
- Normalformen / Normal forms
- Koordinatentransformation / Coordinate transformation
- Allgemeine Lösung der linearen Zustandsgleichung / General solution of a linear state space equation
- Lyapunov-Stabilität / Lyapunov stability
- Steuerbarkeit und Beobachtbarkeit / Controllability and observability
- Stationäre Genauigkeit von Zustandsreglern / Steady-state accuracy of state space controllers
- Beobachter / Observer
- Polvorgabeverfahren / Pole Placement controller design
- Riccati-Regler / LQR controller
- Falb-Wolovitch-Regler / Falb-Wolovitch controller

References:

- K. Michels: Regelungstechnik / Control Engineering (Detailed script in German and English)

German:

- J. Lunze: Regelungstechnik 2
- O. Föllinger: Regelungstechnik
- H. Unbehauen: Regelungstechnik II

English:

- Norman S. Nise: Control Systems Engineering

Learning outcomes / competencies / targeted competencies:

- Sicherer Umgang mit der Zustandsraum-Methodik / Handling of state space methodology
- Entwurf von Zustandsreglern / Design of state space controllers
- Entwurf von Beobachtern / Observer design

Calculation of student workload:

56 h Preparation / follow-up work

68 h Exam preparation

56 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:

English / German

Responsible for the module:

Prof. Dr.-Ing. Kai Michels

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 24/25 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English / German

Description:

Anzahl Prüfungsleistungen: 1

Module courses

Course: Control Theory 1

Frequency:

winter semester, yearly

Language(s) of instruction:

English / German (Ein detailliertes Vorlesungsskript liegt auf Deutsch und Englisch vor / A detailed script in German and English is available)

Contact hours:

4,00

Literature:

K. Michels: Regelungstechnik / Control Engineering (Detailed script in German and English)

Ein detailliertes Vorlesungsskript liegt auf Deutsch und Englisch vor / A detailed script in German and English is available.

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-PrSpa: Project Project

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

none

Learning content:

The content is related to the respective area of research of the individual project. The project is an independent, autonomous, though supervised piece of scientific work. The project is carried out at the laboratories of the Institute of Environmental Physics, at the Institutes of Electrical Engineering, at the Alfred-Wegener-Institute or at a cooperating institute or entity under individual instruction. The scientific investigations necessary for a research project are followed by the preparation of a written report. The topic of the project should - as a rule - be related to the topic of the subsequent Master's Research (Master Thesis).

Learning outcomes / competencies / targeted competencies:

The students should be able to:

- transfer a scientific problem/question into an experimental and/or theoretical study,
- develop successful strategies for the planning and conducting of scientific studies,
- be able to summarize and present preliminary scientific results in a thesis paper.

Calculation of student workload:

360 h Self-study

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Hartmut Bösch

Frequency:

each semester

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 25 / -

Credit points / Workload:

12 / 360 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: module exam

Form of examination:

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

KP (Kombinationsprüfung) mit insgesamt 2 PL (Prüfungsleistungen (Bericht und Vortrag, gemeinsame Note)).

Report + oral presentation.

- successful assessment of the project
- the project is to be done and the final report is to be prepared by one person alone (not a group)
- the final report is to be written in English, an oral presentation will follow the report
- students have 12 weeks to work on their project and prepare the report



Module examination: Kombinationsprüfung

Type of examination: module exam

Form of examination:

The examination is ungraded?

Presentation, oral

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

KP (Kombinationsprüfung) mit insgesamt 2 PL (Prüfungsleistungen (Bericht und Vortrag, gemeinsame Note)).

Report + oral presentation.

- successful assessment of the project
- the project is to be done and the final report is to be prepared by one person alone (not a group)
- the final report is to be written in English, an oral presentation will follow the report
- students have 12 weeks to work on their project and prepare the report

Module courses

Course: Projektarbeit

Frequency:

each semester

Language(s) of instruction:

English

Contact hours:

0,00

Teaching format(s):

Project

Associated module examination:

Kombinationsprüfung

Module 01-PHY-MA-SEM: Science and Exploration Missions

Science and Exploration Missions

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

none

Learning content:

Introduction to completed and planned space missions:

Examples are (i) Gravity Probe A for testing the gravitational redshift, (ii) Gravity Probe B for testing the gravitomagnetic Schiff effect, (iii) Cassini for Saturn exploration and testing the gravitational time delay, (iv) Pioneer for planetary exploration and testing the gravitational field in the Solar system, (v) MICROSCOPE for testing the Equivalence Principle, (vi) LISA for searching for gravitational waves and the technology mission LISA pathfinder, (vii) GRACE and GRACE-FO for satellite based geodesy, (viii) ACES on the ISS for testing relativity and establishing space-based metrology, (ix) further missions testing Special and General Relativity using quantum optics, (x) asteroid and comet missions HAYABUSA and Rosetta.

For each mission the requirements on the payload technology, the spacecraft technology, and on the mission scenario will be derived.

A list of references will be provided at the start of the semester.

Learning outcomes / competencies / targeted competencies:

Participants are able to discuss science cases for space and exploration missions, measurement schemes and payload as well as technology requirements on payload and mission.

Calculation of student workload:

28 h SWS / presence time / working hours

42 h Preparation / follow-up work

20 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Gemäß MPO-Space-ST-02-24: Anzahl Prüfungsleistung: 1

Module courses

Course: Science and Exploration Missions

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Literature:

A list of references will be provided at the start of the semester.

Teaching format(s):

Lecture

Associated module examination:

Modulprüfung

Module 01-ET-MA-SpEI(a): Space Electronics

Space Electronics

Assignment to areas of study:

- Foundations

Content-related prior knowledge or skills:

Basic knowledge of semiconductors, analog and digital circuits

Learning content:

- Radiation environments
- MOS Device and radiation
- Circuit Reliability basics
- Single event effects on analog and digital circuits, memories
- Displacement damage (DD) effects
- Radiation hard device technologies and circuit design
- Noise
- gm/Id Method
- Mismatch
- Background on Analog and Digital simulation
- Process architecture
- Feedback

Learning outcomes / competencies / targeted competencies:

After this course, students are able to:

- describe and characterize noise in electronics circuits,
- apply the gm/Id sizing method to design amplifier circuits for advance CMOS technologies,
- deal with process variations and mismatch,
- understand the frequency behaviour of amplifier circuits,
- understand and size compensation networks,
- use feedback to modify circuit characteristics,
- understand the impact of radiation on the behavior of circuits,
- design radiation-hard circuits.

Calculation of student workload:

34 h Exam preparation

28 h SWS / presence time / working hours

28 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr.-Ing. Alberto Garcia-Ortiz

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Gemäß MPO-Space-ST-02-24: Modulprüfung, PL:1

Module courses

Course: Space Electronics

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Associated module examination:

Modulprüfung

Module 01-PHY-MA-AtSp: Atmospheric Spectroscopy

Atmospheric Spectroscopy

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

No formal requirements.

Learning content:

The lecture will discuss the basics of atmospheric spectroscopy. Atmospheric spectroscopy is directly related to molecular physics. Therefore, molecular physics will also play an important role in the lecture.

Topics will be:

- What is light?
- Prism and grating spectrometer, Fourier Transform spectrometer
- Boltzmann distributions
- Uncertainty principle
- Rotation of molecules
- Vibration of molecules
- Electronic energy levels
- Transitions, transition rules, intensities
- Line widths
- Ground-based and satellite observations
- Retrieval of trace gas concentrations or temperature

A list of references will be provided in the course.

Learning outcomes / competencies / targeted competencies:

Basics of spectroscopy, basics of molecular spectroscopy. Understanding and interpretation of measured spectra with regard to the structure of the molecules. Basics of prism, grating and FTIR-spectroscopy, understanding of remote sensing methods.

Calculation of student workload:

28 h SWS / presence time / working hours

34 h Exam preparation

28 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. rer.nat. Justus Notholt

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: written or oral exam (as announced by the respective lecturer)

Module courses

Course: lecture Atmospheric Spectroscopy

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Associated module examination:

Modulprüfung

Module 01-ET-MA-CNSp: Communication Networks for Space Communication Networks for Space

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

none

Learning content:

Introduction into communication networks. Internet protocols, Internet of things, wireless sensor networks, delay-tolerant networks, opportunistic networks. Space networks: types of spacecraft, orbits and paths, properties of space communication, types of data, quality-of-service requirements, space network architecture, protocols and bearer technologies for space networks, communication infrastructure of governmental and private space agencies.

References:

- J. Kurose/K. Ross: Computer Networking: A Top-Down Approach. 6th ed., Pearson Education, 2013.
- A. Förster: Wireless Sensor Networks. Wiley, 2016.
- J. Taylor: Deep Space Communications. Wiley, 2016.

Learning outcomes / competencies / targeted competencies:

The participants are able to describe exemplary systems of communication networks, know the basic design principles used for communication protocols on the different layers, can explain the special properties of space networks.

Calculation of student workload:

20 h Exam preparation

28 h Preparation / follow-up work

42 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Anna Förster

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

ACHTUNG: Gemäß MPO-Space-ST-02-24

Prüfungstyp = Kombinationsprüfung; Anzahl Studienleistungen: 1, Anzahl Prüfungsleistungen: 1

(Course performance: Successful assessment of homework assignments and a successful poster preparation and presentation)

Module courses

Course: Communication Networks for Space

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

0,00

Literature:

- Walrand, J.: Communication Networks, A first course, WCB/McGraw-Hill 1998, ISBN 0-256-17404-0.
- Tanenbaum, A.S.: Computer Networks, Prentice Hall 1996, ISBN 0-13 349945-6 (and newer editions).
- Ross/Kurose, Computer Networking: A Top Down Approach, 4th ed., Addison-Wesley, July 2007

Additional comments:

3 SWS bei 42 Std. Präsenz

Teaching format(s):

Lecture

Associated module examination:

Kombinationsprüfung

Module 01-PHY-MA-DIP: Digital Image Processing

Digital Image Processing

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

No formal requirements.

Learning content:

- Digital images, sampling
- Grey level transformations, color images
- Image enhancement using filters
- Image analysis methods using segmentation, feature extraction and classification
- Fourier transformation of digital images, linear filters in spatial and frequency domains
- Data compression, image coding, image formats

References:

- K. R. Castleman: Digital Image Processing. Prentice Hall, Englewood Cliffs, 1996.
- R. C. Gonzalez, R. E. Woods: Digital Image Processing. Addison-Wesley, Second Edition, 2002.
- B. Jähne: Digital Image Processing. Springer, 6th edition, 2005.
- J.C. Russ and F.B. Neal: The Image Processing Handbook. CRC Press, 7th edition, 2017. ISBN 9781315214115. doi: 10.1201/b18983.
- R. A. Schowengerdt: Remote Sensing, Models and Methods for Image Processing. Academic Press, 1997.

Learning outcomes / competencies / targeted competencies:

Fundamentals, basic concept and methods of digital image processing, enabling the students to identify and understand image processing problems (encountered in Environmental Physics, Space Science etc.) and to find appropriate solutions

Calculation of student workload:

28 h Preparation / follow-up work

28 h SWS / presence time / working hours

34 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Dr. Gunnar Spreen

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 20/21 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: combination exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / 1 / -

Language(s) of instruction:

English

Description:

Examination performance: written exam (or as announced by the respective lecturer)

Course performance: portfolio (series of exercise sheets or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Digital Image Processing

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Kombinationsprüfung

Module 01-PHY-MA-GeoGra: Geodesy and Gravity

Geodesy and Gravity

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

none

Learning content:

Classical geodesy

- Repetition of Newtonian gravitational theory
- Multipole moments of the Earth and the gravitational field of the Earth
- Definition of the geoid on the rotating Earth
- Equation of motion for satellites
- Calculation of satellite orbits
- Description of orbits for satellite formation flight and extraction of the gravitational field

Relativistic geodesy

- Elements of relativistic gravity theory
- Post-Newtonian solution for the gravitational field of the Earth
- Definition of the geoid
- Clocks in the gravitational field: clock geodesy
- Relativistic satellite orbits, basic effects

Learning outcomes / competencies / targeted competencies:

The students gain knowledge of notions of nonrelativistic gravity theory, knowledge of basic notions of geodesy, an understanding of methods to measure the gravitational fields, knowledge of basic principles of relativistic gravity and an understanding of clock geodesy.

Calculation of student workload:

20 h Exam preparation

28 h SWS / presence time / working hours

42 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Gemäß MPO-Space-ST-02-24, Anzahl Prüfungsleistung: 1

Module courses

Course: Geodesy and Gravity

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Associated module examination:

Modulprüfung

Module 01-PHY-MA-GNSS: The Global Navigation Satellite System

The Global Navigation Satellite System

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

Newtonian mechanics

Learning content:

Understanding of the working principles of global navigation satellite systems (GNSS).

This consists on (i) the physical requirements regarding the main working principles. Here the Earth's gravity field, satellite orbits, clocks, electromagnetic signal propagation in the Earth's atmosphere, and the targeted accuracy are discussed.

In the second step (ii) the theoretical analysis of the whole problem has to be carried through. This includes basic effects on moving clocks (special relativistic time dilation) and clocks in gravitational fields (gravitational redshift) and the calculation of the position from the clock signals. Moreover, theoretical concepts within geodesy regarding reference surfaces and coordinate systems such as WGS84 will be introduced.

In the third part (iii) the technological realization is studied.

Learning outcomes / competencies / targeted competencies:

Physical and theoretical principles of positioning, navigation, GNSS satellites, payloads, clocks; Technology requirements of GNSS operation; Scientific use of GNSS

Calculation of student workload:

28 h Preparation / follow-up work

28 h SWS / presence time / working hours

34 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

PD Dr. Eva Hackmann

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English / German

Module courses

Course: The Global Navigation Satellite System

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Literature:

Werner Mansfeld: Satellitenortung und Navigation. Grundlagen, Wirkungsweisen und Anwendung globaler Satellitennavigationssysteme. Vieweg, Wiesbaden 2010.

Manfred Bauer: Vermessung und Ortung mit Satelliten. Globale Navigationssysteme (GNSS) und andere satellitengestützte Navigationssysteme. Wichmann, Berlin 2011

B. Hoffmann-Wellenhof, H. Lichtenegger, and J. Collins: GPS - Theory and Practice, (Springer, Wien and New York, 2001)

N. Ashby "Relativity in the Global Positioning System", Living Reviews in Relativity

P. Teunissen, O. Montenbruck "Springer Handbook of Global Navigation Satellite Systems", Springer

B. Hoffmann-Wellenhof, H. Lichtenegger, E. Wasle "GNSS – Global Navigation Satellite Systems", Springer

ESA "GNSS data processing", https://gssc.esa.int/navipedia/GNSS_Book/ESA_GNSS-Book_TM-23_Vol_I.pdf

Teaching format(s):

Lecture

Associated module examination:

Modulprüfung

Module 01-PHY-MA-LSpa1: Space Lab Part 1

Space Lab Part 1

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

-

Learning content:

A set of practical measurements and modelling experiments on surface properties, atmospheric trace gas amounts, ocean currents and other environmental parameters is performed by the students under supervision of tutors. The measurements and modelling results obtained in the lab will then be analysed, and the experiment, its background and the results as well as their interpretation be documented in a written report.

Learning outcomes / competencies / targeted competencies:

Participants learn to perform measurements central to Space Sciences and Technologies using scientific techniques and methods. They learn to analyse the measurements and to document the results in a written report.

Calculation of student workload:
Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

PD Dr. Andreas Richter

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 20 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: combination exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / 1 / -

Language(s) of instruction:

English

Module courses

Course: Space Lab Part 1

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Laboratory class

Associated module examination:

Kombinationsprüfung

Module 01-ET-MA-LSpa2: Space Lab Part 2

Space Lab Part 2

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

-

Learning content:

Application of control basics, measurements of Embedded Systems and Communications.

Learning outcomes / competencies / targeted competencies:

Participants learn

- the basics of control and measurement techniques in Space Sciences and Technologies;
- the basic structure and concepts of communications systems for space;
- implementation and visualization of communications algorithms and concepts via Matlab or Python;
- performance measurements of communication protocols using a simulation tool.

Calculation of student workload:**Are there optional courses in the modules?**

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Anna Förster

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 20 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / 1 / -

Language(s) of instruction:

English

Module courses

Course: Space Lab Part 2

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Laboratory class

Associated module examination:

Modulprüfung

Module 01-ET-MA-SAMS(a): Sensors and Measurement Systems

Sensors and Measurement Systems

Assignment to areas of study:

- Remote Sensing and Communication

Content-related prior knowledge or skills:

none

Learning content:

The class will cover fundamentals of sensor science starting at the underlying physical mechanisms, different sensor devices, and integrated sensor systems. Process technology used to fabricate sensors will be discussed.

The following sensors will be addressed:

- Thermal Sensors
- Force and Pressure Sensors
- Inertial Sensors
- Magnetic Sensors
- Flow Sensors

Reference:

Walter Lang: Sensors and Measurement systems, ISBN-10: 877022028X

Learning outcomes / competencies / targeted competencies:

Students will gain an overview on different sensor technologies that will enable them to select a particular sensor for a defined application. They will be able to understand the working mechanism of various sensors and to make suggestions on how to improve their performance. Furthermore, they will be able to understand and optimize the different processing steps of a complex sensor module.

Calculation of student workload:

56 h SWS / presence time / working hours

56 h Preparation / follow-up work

68 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr.-Ing. Björn Lüssem

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Anzahl der Prüfungsleistungen: 1

Module courses

Course: Sensors and Measurement Systems

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Literature:

Walter Lang: Sensors and Measurement systems, ISBN-10: 877022028X

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-PHY-MA-RSOC: Remote Sensing of Ocean and Cryosphere

Remote Sensing of Ocean and Cryosphere

Assignment to areas of study:

- Specialization Areas / Physics for Space Observation

Content-related prior knowledge or skills:

-

Learning content:

- Concepts for satellite remote sensing of the ocean and cryosphere
- Microwave radar and radiometer observations of sea and land ice and of sea surface temperature and salinity
- Altimetry for sea surface height, circulation, sea level and ice thickness change
- Optical satellite data for ocean color and sea ice
- Error analysis and statistics
- Practical examples and applications to use satellite data sets from oceanography and cryosphere
- Satellite data processing

A list of references will be provided at the start of the semester.

Learning outcomes / competencies / targeted competencies:

Students gain knowledge in basics and application of remote sensing of sea ice extent, type, drift and thickness, ice shelves and glaciers, sea surface height, winds over the ocean, waves, ocean color, surface temperature and salinity, sea level rise, ocean color and other remote sensing applications for ocean and cryosphere.

Calculation of student workload:

56 h Preparation / follow-up work

56 h SWS / presence time / working hours

68 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Dr. Gunnar Spreen

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Prüfungsleistung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

ACHTUNG: Gemäß MPO-Space-ST-02-24, Prüfungstyp = Teilprüfung; Anzahl Studienleistung: 1, Anzahl Prüfungsleistung: 1

Prüfungsleistung: 3 CP

Studienleistung: 3 CP



Module examination: Studienleistung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

ACHTUNG: Gemäß MPO-Space-ST-02-24, Prüfungstyp = Teilprüfung; Anzahl Studienleistung: 1, Anzahl Prüfungsleistung: 1

Prüfungsleistung: 3 CP

Studienleistung: 3 CP

Module courses

Course: Remote Sensing of Ocean and Cryosphere

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Literature:

A list of references will be provided at the start of the semester.

Teaching format(s):

Associated module examination:

Prüfungsleistung

Studienleistung

Module 01-PHY-MA-CliS1: Climate System I Climate System I

Assignment to areas of study:

- Specialization Areas / Physics for Space Observation

Content-related prior knowledge or skills:

No formal requirements.

Learning content:

- Greenhouse climate
- Climate feedbacks
- Energy transport in the climate system
- Ocean's role in climate
- Physical attribution of ongoing climate change and the 1.5° warming threshold

References:

- Pierrehumbert, R.T.: Principles of Planetary Climate, Cambridge University Press, 2010
- more references will be provided in the course

Learning outcomes / competencies / targeted competencies:

- Understanding of the physical basis of climate change
- Energy balance models (without and with transport)
- Implementation of climate feedbacks in simple energy balance models
- Understanding of the physics behind ongoing climate change
- Understanding of the IPCC framework for attributing climate change
- Computation of equilibrium temperature from energy balance models, feedbacks, etc.
- Computation of oceans role in climate (heat uptake and AMOC change)

Calculation of student workload:

28 h SWS / presence time / working hours

34 h Exam preparation

28 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Torsten Kanzow

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: combination exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / 1 / -

Language(s) of instruction:

English

Description:

Examination performance: written exam (or as announced by the respective lecturer)

Course performance: portfolio (series of exercise sheets or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Climate System I

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Kombinationsprüfung

Module 01-PHY-MA-AtCM1: Atmospheric Chemistry Modelling: Part 1 (Theory)

Atmospheric Chemistry Modelling: Part 1 (Theory)

Assignment to areas of study:

- Specialization Areas / Physics for Space Observation

Content-related prior knowledge or skills:

No formal requirements

Learning content:

- Concept of chemistry transport models
- Atmospheric Chemical Composition/Processes
- Model equations and numerical approaches focusing on the:
 - a) formulation of atmospheric rates
 - b) numerical methods for chemical systems
- Surface fluxes/emissions
- Observations and model evaluations
- Applied Mathematical Methods and Data Analysis for atmospheric chemistry

A list of references will be provided in the course.

Learning outcomes / competencies / targeted competencies:

Participants will have the chance to:

- get a theoretical overview of the concepts of numerical atmospheric chemistry modelling
- review fundamentals of atmospheric chemistry and physics
- formulate model equations and numerical (differential) approaches for various systems focusing on atmospheric chemistry mechanisms
- assess the role of chemistry transport models as components of the atmospheric observing system

Concepts of inverse modelling will be also presented

Calculation of student workload:

28 h SWS / presence time / working hours

20 h Exam preparation

42 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Mihalis Vrekoussis

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Oral

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: oral exam (or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Atmospheric Chemistry Modelling: Part 1 (Theory)

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-RFC(a): RF Frontend Devices and Circuits

RF Frontend Devices and Circuits

Assignment to areas of study:

- Specialization Areas / Information Technologies for Space none

Content-related prior knowledge or skills:

Learning content:

- Two-port circuits
- Noise in electronic circuits (thermal noise, noise figure, noise temperature, Friis formula, antenna noise, etc.)
- Fundamentals of non-linear devices (gain compression, desensitization, IP2, IP3 points, ...)
- RF devices & RF circuits and frontends (amplifier, mixer, oscillator)

A list of references is given in the manuscript.

Learning outcomes / competencies / targeted competencies:

After successful completion of this module the students:

- can describe two-port circuits by matrices (Z, Y, ABCD, ...)
- know the basic schematics of typical transmitter and receiver circuits
- can analyze the noise performance of receiver circuits
- can perform a signal and noise budget analysis of typical wireless communication links (microwave backhaul systems, mobile communications, satellite communications)
- can analyze the non-linear behavior of practical RF devices (amplifier, mixer)
- can design and analyze fundamental oscillator topologies
- are able to discuss the pros and cons of different RF frontend architectures and can design first basic analogue RF frontend circuits.

Calculation of student workload:

56 h SWS / presence time / working hours

68 h Exam preparation

56 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr.-Ing. Martin Schneider

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Anzahl Prüfungsleistungen: 1

Module courses

Course: RF Frontend Devices and Circuits

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-BiM: BioMEMS

BioMEMS

Assignment to areas of study:

- Specialization Areas / Information Technologies for Space none

Content-related prior knowledge or skills:**Learning content:**

- Organisation, introduction, basics of microfluidics and BioMEMS
- Flow control: valves and pumps
- Sensors and analysis in BioMEMS devices
- Technology and packaging
- Examples of BioMEMS devices
- Modeling and simulation of microfluidic structures

A list of references will be provided at the start of the semester.

Learning outcomes / competencies / targeted competencies:

An overview is given of the developments in the area of microfluidic and BioMEMS devices from the early start (where especially silicon integrated valves and pumps were investigated) to the lab-on-a-chip devices of today. The functionality of the sensors and actuators, the technologies applied, and the design of fluidic chips will be discussed. Some basic fluidics aspects will be presented and a practical in which COMSOL is used for the simulation of microfluidic elements is included. A series of examples of currently investigated BioMEMS devices will be shown, e.g. chips for capillary electrophoresis, cytometry and optofluidics.

After this course, students are able to:

- understand the basics of microfluidics,
- understand and explain the functioning of μ fluidic devices,
- apply characterization parameters for (elements of) μ fluidic and BioMEMS devices,
- understand fabrication technologies for microfluidic and BioMEMS devices.

Calculation of student workload:

28 h Self-study

68 h Exam preparation

28 h Preparation / follow-up work

56 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr.-Ing. Michael Vellekoop

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Anzahl Prüfungsleistungen: 1

Module courses

Course: BioMEMS

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Literature:

A list of references will be provided at the start of the semester.

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-DiTe(a): Digital Technology

Digital Technology

Assignment to areas of study:

- Specialization Areas / Information Technologies for Space

Content-related prior knowledge or skills:

Learning content:

- Timing strategies
- Non-programmable hardware modules
- Programmable hardware modules
- Selected algebraic and Boolean operations
- Introduction to digital coding

Learning outcomes / competencies / targeted competencies:

Die Studierenden

- erlernen spezielle Fähigkeiten zur Realisierung funktionsspezifischer digitaler, kombinatorischer und komplexer sequentieller Schaltungen;
- erwerben Grundwissen zur Realisierung digitaler Module;
- erlernen verschiedene Strategien für die Realisierung digitaler Module (z.B. Datenpfad+Steuerpfad, Synchron vs. Asynchron, Programmierbarkeit, ...);
- beherrschen Entwurfs- und Analysemethoden von Schaltnetzen und Schaltwerken;
- erlernen spezielle Fähigkeiten zur Realisierung funktionsspezifischer digitaler Systeme.

Calculation of student workload:

68 h Exam preparation

56 h SWS / presence time / working hours

56 h Self-study

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr.-Ing. Alberto Garcia-Ortiz

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations**Module examination:** Modulprüfung**Type of examination:****Form of examination:**

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English / German

Description:

Anzahl Prüfungsleistungen: 1

Module courses**Course:** Digital Technology**Frequency:**

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Teaching format(s):**Associated module examination:**

Modulprüfung

Module 01-PHY-MA-BGC: Biogeochemistry

Biogeochemistry

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

No formal requirements

Learning content:

- Global biochemical cycles of elements
- Important biophysical processes in atmosphere and ocean
- Carbon, methane, nitrogen and water cycles
- Greenhouse gases

A list of references will be provided in the course.

Learning outcomes / competencies / targeted competencies:

Advanced biogeochemistry

Calculation of student workload:

28 h SWS / presence time / working hours

34 h Exam preparation

28 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Annette Ladstätter-Weißenmayer

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 20/21 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Oral

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: oral exam (or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Biogeochemistry

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-CCod(a): Channel Coding Channel Coding

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

Basics of Communication Technologies or equivalent

Learning content:

- Information Theory
- Blockcodes
- Convolutional Codes
- Concatenated Codes

Learning outcomes / competencies / targeted competencies:

After this course, the students should be able to

- understand the fundamentals of information theory and the concept of channel coding;
- understand the fundamentals of block and convolutional codes;
- apply encoding and decoding algorithms;
- understand the concept of concatenated codes and iterative decoding.

Calculation of student workload:

28 h Preparation / follow-up work

34 h Exam preparation

28 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Dr.-Ing. Dirk Wübben

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Gemäß MPO-Space-ST-02-24, Anzahl Prüfungsleistungen: 1.

Gemäß MPO-CIT-02-22 und AeO_MSc-CIT02-22, Anzahl Prüfungsleistungen: 1.

Module courses

Course: Channel Coding

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-PHY-MA-CliM1: Climate Modelling: Part 1

Climate Modelling: Part 1

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

No formal requirements

Learning content:

Introduction to Climate Modelling

Types of Climate Models

Components of Atmosphere Ocean General Circulation Models (AO-GCMs)

Fundamentals and representation in GCMs: Radiation

Fundamentals and representation in GCMs: Dynamics of the Atmosphere

Fundamentals and representation in GCMs: Ocean and sea ice component

Fundamentals and representation in GCMs: Land component

Parametrizations in climate models

Steps in climate model formulation

Frequently Asked Questions IPCC Assessment Reports

Introduction to the ICON climate model

Computational exercises with the ICON model: running a climate model

Computation exercises in Python: plotting ICON model output

A list of references will be provided in the course.

This course is given as a block course.

Learning outcomes / competencies / targeted competencies:

Overview how a climate model works and how to set up a climate model simulation (without covering all details); getting some first experience with running a climate model and plotting its output using python

Calculation of student workload:

42 h Preparation / follow-up work

28 h SWS / presence time / working hours

20 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Veronika Eyring

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 20/21 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: written exam or oral exam (as announced by the respective lecturer)

Module courses

Course: block course (lecture + example classes) Climate Modelling: Part 1

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-PHY-MA-Dyn1: Dynamics I Dynamics I

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

No formal requirements.

Learning content:

- Governing equations
- Basic conservation laws
- Balances
- Elementary applications of the basic equations
- Circulation and vorticity
- Planetary boundary layer and large-scale dynamics
- Rossby waves

References:

- Holton: An Introduction to Dynamic Meteorology, Elsevier Academic Press
- Marshall and Plumb: Atmosphere, Ocean, and Climate Dynamics, An Introductory Text, Academic Press, 2008
- Wallace and Hobbs, Atmospheric Science: An Introductory Survey, Academic Press

Learning outcomes / competencies / targeted competencies:

Understanding of the basic dynamical processes in atmosphere and ocean; learning how to interpret physical equations physically

Calculation of student workload:

56 h Preparation / follow-up work

56 h SWS / presence time / working hours

68 h Exam preparation

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Thomas Jung

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 20/21 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Examination performance: written exam (or as announced by the respective lecturer)

Module courses

Course: lecture + example classes Dynamics I

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-EngE: Engineering Ethics

Engineering Ethics

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

None

Learning content:

- Basic moral concepts
- Basic moral theories and values and their rationale
- Codes of Ethics (examples from Associations and Agencies)
- Case Studies from engineering
- Professional ideals
- Basic aspects of environmental ethics

Learning outcomes / competencies / targeted competencies:

After the course the students will be able to

- discuss and apply professional codes of ethics;
- distinguish normative from descriptive judgements;
- describe basic norms, values and ethical theories;
- determine conditions of responsibility;
- apply norms and theories to concrete cases in engineering and identify ethical issues at different stages.

Calculation of student workload:

28 h Preparation / follow-up work

34 h Exam preparation

28 h SWS / presence time / working hours

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Dagmar Borchers

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 20/21 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: combination exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / 1 / -

Language(s) of instruction:

English

Module courses

Course: Engineering Ethics

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Seminar

Associated module examination:

Kombinationsprüfung

Module 01-ET-MA-InS(a): Integrated Circuits

Integrated Circuits

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

none

Learning content:

- Noise
- gm/Id Method
- Mismatch
- Two-pole opamps (OTA)
- Feedback

A list of references will be provided at the start of the semester.

Learning outcomes / competencies / targeted competencies:

After this course, students are able to:

- describe and characterize noise in electronics circuits,
- apply the gm/Id sizing method to design amplifier circuits for advance CMOS technologies,
- deal with process variations and mismatch,
- understand the frequency behaviour of amplifier circuits,
- understand and size compensation networks,
- use feedback to modify circuit characteristics.

Calculation of student workload:

68 h Exam preparation

56 h SWS / presence time / working hours

56 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr.-Ing. Steffen Paul

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Description:

Anzahl Prüfungsleistungen: 1

Module courses

Course: Integrated Circuits

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Literature:

A list of references will be provided at the start of the semester.

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-ML: Machine Learning for Swarm Exploration

Machine Learning for Swarm Exploration

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

Basics in linear algebra and calculus, some probability theory and basics in signal processing

Learning content:

- Why swarm exploration – some motivational examples with applications in space and on Earth
- Preliminaries: selected mathematical formalism (vector spaces, matrices, representation and approximations in vector spaces, least squares, convex optimization)
- Recap of probability and statistics (calculus of probabilities, moments, Bayesian theory)
- Machine learning tools (supervised learning, linear regression, kernel methods, neural networks, impact of regularization, sparsity and compressed sensing)
- Models for multi-agent networks (connected network models, distributed inference strategies)
- Distributed machine learning and exploration (models for static spatial regression, information-theoretic exploration approaches, Bayesian sequential methods for learning and exploration)
- Discussion of several practical examples of swarm exploration solutions (cooperative localization, information-driven sparse mapping of magnetic fields, exploration of sparse gas sources using a swarm of mobile robots)

Literature:

- Todd K. Moon, Wynn C. Stirling: Mathematical Methods and algorithms for signal processing
- Jose M. Bernardo, Andrian F.M. Smith : Bayesian theory
- Christopher M. Bishop: Pattern Recognition and Machine Learning
- Ali H. Sayed: Adaptation, Learning, and Optimization over Networks

Learning outcomes / competencies / targeted competencies:

As outcome, the students should be able to:

- Understand key concepts in distributed information processing over networks,
- Explain and apply mathematical tools needed to implement classical machine learning algorithms in distributed settings

Calculation of student workload:**Are there optional courses in the modules?**

no

Language(s) of instruction:

English

Responsible for the module:

Prof.Dr.-Ing. Armin Dekorsy

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 19/20 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Module courses

Course: Machine Learning for Swarm Exploration

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Associated module examination:

Module 01-PHY-MA-PCSS: Philosophy of Cosmology, Space and Space Travel Philosophy of Cosmology, Space and Space Travel

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

None

Learning content:

This course covers philosophical questions about cosmology and about the exploration of terra incognita related to space. First, we cover the meaning of exploration for mankind in general (exploration of new territories as well as of laws of the physical world and laws in general). Second, we specialize to questions related to space: What is the idea behind a finite or infinite world? What does the exploration of space mean for the “position” of mankind within the Universe, for the world view of human beings? What would it mean for mankind if the search for extraterrestrial life will be successful? In what sense can cosmology missions “uncover” the dynamics of the universe from the Big Bang to the far future? What concept of time is involved here and what counts as evidence and why?

Learning outcomes / competencies / targeted competencies:

- Knowledge of basic notions from the philosophy of the natural sciences (natural law, space, time, infinity, ...)
- Basic insights into the aims of scientific inquiry and the generation of scientific knowledge (by means of examples from the history of cosmology)
- Ideas involved in human self-understanding related to “other worlds” or extraterrestrial life
- Basic knowledge of cosmology.

Calculation of student workload:

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:

winter semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

- / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Module courses

Course: Philosophy of Cosmology, Space and Space Travel

Frequency:

winter semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Literature:

Will be announced at the beginning of the course.

Teaching format(s):

Seminar

Associated module examination:

Modulprüfung

Module 01-PHY-MA-RingSp: Fascination Space Fascination Space

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

none

Learning content:

Overview over a number of actual topics in space sciences and fundamental physics

- Global biochemical cycles of elements, important biophysical processes in atmosphere and ocean, carbon-, methane-, nitrogen and water cycle, greenhouse gases
- Quantum technologies in space
- Test of the Equivalence principle
- The Pioneer Anomaly
- Satellite based geodesy
- Clocks in space – fundamental physics and practical applications
- Exoplanets
- Asteroids

Learning outcomes / competencies / targeted competencies:

Overview over a number of actual topics in space sciences

Calculation of student workload:

30 h Exam preparation

28 h SWS / presence time / working hours

32 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Annette Ladstätter-Weißenmayer

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 26 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Kombinationsprüfung

Type of examination: module exam

Form of examination:

Oral examination (single)

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English

Module courses

Course: Fascination Space

Frequency:

summer semester, yearly

Contact hours:

2,00

Teaching format(s):

Lecture

Language(s) of instruction:

German

Associated module examination:

Kombinationsprüfung

Module 01-PHY-MA-SpTel: Space Telescopes

Space Telescopes

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

Basic optics

Learning content:

Introduction of completed and planned space telescope missions, payloads and instruments

Possible space telescopes to be discussed are (i) Hubble Space Telescope, (ii) James Webb Space Telescope, (iii) Telescopes searching for Exo-planets such as Kepler or PLATO (iv) X-Ray telescopes such as Chandra, XMMNewton and Athena (v) Gamma-Ray Telescopes such as Fermi and INTEGRAL (vi) CMB observatories such as Planck (vii) LISA for the observation of gravitational waves

The aim is to discuss for each Space Telescope

- the science objectives of the mission,
- the mission scenario and operational aspects,
- the design of the telescope and requirements driving the design,
- the instruments and the underlying technologies.

References:

- Max Born, Emil Wolf: Principles of Optics

Learning outcomes / competencies / targeted competencies:

- Understand the basic aspects of science cases for several space telescopes
- Learn about mission scenarios for completed, ongoing and planned space telescopes operating in various regions of the electromagnetic spectrum
- Learn about operation principles and technological aspects of space telescope payloads

Calculation of student workload:

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. rer. nat. Claus Lämmerzahl

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 20 / -

Credit points / Workload:

3 / 90 hours

Module examinations

Module examination: Modulprüfung

Type of examination: module exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Module courses

Course: Space Telescopes

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

2,00

Teaching format(s):

Lecture

Associated module examination:

Modulprüfung

Module 01-ET-MA-WCom(a): Wireless Communications

Wireless Communications

Assignment to areas of study:

- Electives Modules

Content-related prior knowledge or skills:

Basics of Communication Technologies

Learning content:

- Mobile Radio Channel (WSSUS channel, delay spread, coherence bandwidth, frequency selectivity, doppler spread, coherence time, time selectivity)
- Non-frequency selective channel, bit error rate
- Diversity (time/frequency), maximum ration combining
- Multi Carrier Transmission (principles, ambiguity function, waveform design)
- Othogonal Frequency Division Multiplexing (OFDM), OFDMA
- Code-Division-Multiple-Access (e. g. DS-CDMA)

A list of references will be provided at the start of the semester.

Learning outcomes / competencies / targeted competencies:

After this course, the students will be able to

- understand the fundamentals of mobile communication channels (Doppler-Spread, Delay-Spread, Angular-Spread, Frequency and time selectivity) as well as channel models (Rice/Rayleigh fading);
- explain the concept of communication diversity and related techniques;
- understand the principles of mapping information onto F/T-grids, to explain the ambiguity function, inter-carrier and inter-symbol-interference, to design multi-carrier-systems like OFDM, FBMC);
- understand the principle of separating signals in the code domain, to explain the design of (composite) spreading sequences, and to design CDMA receivers used in modern communication systems.

Calculation of student workload:

68 h Exam preparation

56 h SWS / presence time / working hours

56 h Preparation / follow-up work

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof.Dr.-Ing. Armin Dekorsy

Frequency:

summer semester, yearly

Duration:

1 semester[s]

The module is valid since / The module is valid until:

SoSe 24 / -

Credit points / Workload:

6 / 180 hours

Module examinations

Module examination: Modulprüfung

Type of examination:

Form of examination:

Written examination

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

English / German

Description:

Anzahl der Prüfungsleistungen: 1

Module courses

Course: Wireless Communications

Frequency:

summer semester, yearly

Language(s) of instruction:

English

Contact hours:

4,00

Literature:

A list of references will be provided at the start of the semester.

Teaching format(s):

Lecture

Tutorial

Associated module examination:

Modulprüfung

Module 01-ET-MA-ThsSpa: Master Thesis (incl. Colloquium)
Master Thesis (incl. Colloquium)

Assignment to areas of study:

- Master Thesis

Content-related prior knowledge or skills:

Proof of at least 75 CP and thus

a) passing all the compulsory modules of the study sections

Foundations (30 CP) and Remote Sensing and Communication (27 CP)

b) having obtained at least 6 CP out of the compulsory elective modules of the chosen specialization

c) the module „Project“ (12 CP)

Learning content:

The students learn to:

- transfer a scientific problem/question into an experimental and/or theoretical study,
- develop successful strategies for the planning and conducting of scientific studies,
- conduct a critical evaluation, assessment and discussion of own scientific results,
- summarize and present scientific results in a thesis and in a colloquium.

Learning outcomes / competencies / targeted competencies:

The students are enabled to transfer a scientific problem/question into an experimental and/or theoretical study, to develop successful strategies for the planning and conducting of scientific studies and to summarize and present scientific results.

Calculation of student workload:

Are there optional courses in the modules?

no

Language(s) of instruction:

English

Responsible for the module:

Prof. Dr. Hartmut Bösch

Frequency:

each semester

Duration:

1 semester[s]

The module is valid since / The module is valid until:

WiSe 17/18 / -

Credit points / Workload:

30 / 900 hours

Module examinations

Module examination: Masterarbeit

Type of examination: module exam

Form of examination:

Master Thesis

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Successful assessment of the Master's Thesis (graded).



Module examination: Kolloquium

Type of examination: module exam

Form of examination:

Colloquium

The examination is ungraded?

no

Number of graded components / ungraded components / prerequisites of the examination:

1 / - / -

Language(s) of instruction:

English

Description:

Successful colloquium to the Master's Thesis (graded)

Master's thesis and colloquium are marked in a common grade. The grade for the master's thesis will be weighted by 75% and the colloquium by 25%.

Module 01-PHY-MA-0 Space-ST: Additional courses master program Space-ST

Additional courses master program Space-ST

Assignment to areas of study:

- Additional Courses

Content-related prior knowledge or skills:

none

Learning content:

Learning outcomes / competencies / targeted competencies:

In diesem "Modul", das nicht Bestandteil der Prüfungsordnung ist, informieren wir Sie über Veranstaltungen, die aufgrund der neuen Darstellungsstruktur in Stud.IP sonst nicht mehr auffindbar wären. Es können Seminare, Informationsveranstaltungen oder General Studies Angebote sein.

Sollten Sie erwägen, in einer der Veranstaltungen eine Prüfung abzulegen, erkundigen Sie sich bitte bei Ihrer Dozentin/Ihrem Dozenten über die korrekten Anmeldemodalitäten.

In this "module", which is not part of the examination regulations, we inform you about courses that would otherwise no longer be visible in Stud.IP due to the new display structure. These may be seminars, information events or general studies courses.

If you consider taking an examination in one of the courses, please ask your lecturer about the correct registration modalities.

Calculation of student workload:

Are there optional courses in the modules?

yes

Language(s) of instruction:

German

Responsible for the module:

N.N.

Frequency:

Duration:

The module is valid since / The module is valid until:

WiSe 23/24 / -

Credit points / Workload:

0 / 0 hours

Module examinations

Module examination: ohne Prüfung

Type of examination: module exam

Form of examination:

Announcement at the beginning of the semester

The examination is ungraded?

yes

Number of graded components / ungraded components / prerequisites of the examination:

- / - / -

Language(s) of instruction:

German

Module courses

Course: Additional courses master programm Space-ST

Frequency:

Language(s) of instruction:

German

Contact hours:

0,00

Teaching format(s):

Lecture

Tutorial

Seminar

Study group

Self-study unit

Associated module examination: