UNIVERSITÄT LEIPZIG

Faculty of Physics and Earth Sciences

Course Program

Master of Science

Meteorology

Valid from winter semester 2020/21

This English translation is intended to allow English-speaking readers a better understanding of the Examination and Study Regulations. It is solely for information purposes and only the official German version is legally binding.

1 Study Plan and Course Program

1.1 Study Plan – Master of Science Meteorology

	Semester:	1	2	3	4
Compulsory Area	Meteorology	P1 – Dynamics and Synoptics **6 CP** / 2+2 CHW	P3 – Advanced Weather Discussions **5 CP** / 2+1 CHW	P5 – Current Research in Meteorology **10 CP** / 1+2 CHW	
Compulsory Area	Meteorology	P2 – Atmospheric Radiation **5 CP** / 2+1 CHW	P4 – Dynamics of the Global Climate System **6 CP** / 2+2 CHW	P6 – Advanced Scientific Working in Meteorology **10 CP** / 1+2 CHW	
Compulsory Area	Thesis				Master Thesis **30 CP**
Elective Area	General Meteorology	General Meteorology – **10 CP**; 2 Modules of: A1 – Atmospheric Aerosol, A2 – Atmospheric Chemistry - The Multiphase System, A3 – Numerical Weather Prediction and Climate Modelling, A4 – Polar Climate, A5 – Cloud Physics, A6 – Dust in the Atmosphere, A7 – Atmospheric Trace Substances and their Modelling			
Elective Area	Experimental Meteorology	Experimental Meteorology – **10 CP**; 2 Modules of: E1 – Airborne Physical Measuring Methods, E2 – Ground-based Radar and Microwave Remote Sensing, E3 – Upper Atmosphere, E4 – Active Remote Sensing with Lidar, E5 – Spaceborne Remote Sensing			
Elective Area	Theoretical Meteorology	Theoretical Meteorology – **10 CP**; 2 Modules of: T1 – Dynamics of the Middle Atmosphere, T2 – Atmospheric Models: Parameterizations and Scales, T3 – Radiative Transfer Lab, T4 – Scattering and Atmospheric Optics, T5 – Terrestrial Radiative Transfer, T6 – Data Assimilation			
Elective Area	Physics	Physics – **8 CP**; 1 Module of: Experimental Physics 3 or Theoretical Physics 1, 2, 4, 5 from B.Sc. IPSP (English) or Experimental Physics 3, 4, 5 or Theoretical Physics 1, 2, 3, 4 from B.Sc. Physik (German)			
Elective Area	Leipzig University	Free Elective Area – **10 CP**: Either 2 additional Modules from the Elective Areas in Meteorology or any Module(s) from other study programs			

* CHW: contact hours per week (usually lecture + seminar or exercises); CP: credit points

1.1.1 Compulsory Area

Semester	Module Number	Title of Compulsory Module	CP
1	12-111-1001	P1 – Dynamics and Synoptics	6
1	12-111-1019	P2 – Atmospheric Radiation	5
2	12-111-1020	P3 – Advanced Weather Discussions	5
2	12-111-1021	P4 – Dynamics of the Global Climate System	6
3	12-111-1022	P5 – Current Research in Meteorology	10
3	12-111-1023	P6 – Advanced Scientific Working in Meteorology	10
4		Master Thesis	30
		Total	**72**

1.1.2 Elective Area

Semester	Module Number	Title of (Compulsory) Elective Module	CP
1 – 3		***General Meteorology***	***10***
1/3	12-111-1024	A1 – Atmospheric Aerosol	5
1	12-111-1025	A2 – Atmospheric Chemistry - The Multiphase System	5
1/3	12-111-1026	A3 – Numerical Weather Prediction and Climate Modelling	5
2	12-111-1043	A4 – Polar Climate	5
2	12-111-1028	A5 – Cloud Physics	5
2	12-111-1042	A6 – Dust in the Atmosphere	5
1/3	12-111-1041	A7 – Atmospheric Trace Substances and their Modelling	5
1 – 3		***Experimental Meteorology***	***10***
1/3	12-111-1035	E1 – Airborne Physical Measuring Methods	5
1/3	12-111-1036	E2 – Ground-based Radar and Microwave Remote Sensing	5
2	12-111-1037	E3 – Upper Atmosphere	5
1/3	12-111-1038	E4 – Active Remote Sensing with Lidar	5
2	12-111-1039	E5 – Spaceborne Remote Sensing	5
1 – 3		***Theoretical Meteorology***	***10***
1/3	12-111-1029	T1 – Dynamics of the Middle Atmosphere	5
2	12-111-1031	T2 – Atmospheric Models: Parameterizations and Scales	5
2	12-111-1040	T3 – Radiative Transfer Lab	5
1/3	12-111-1032	T4 – Scattering and Atmospheric Optics	5
2	12-111-1033	T5 – Terrestrial Radiative Transfer	5
2	12-111-1034	T6 – Data Assimilation	5
1 – 3		***Physics***	***8***
either 1 Module from the (English) Bachelor Program "B.Sc. IPSP":			
1/3	12-PHY-BIEP3	Experimental Physics 3 - Electromagnetic Waves and Foundations of Quantum Physics	8
1/3	12-PHY-BIPTP1#	Theoretical Physics 1 - Classical Mechanics 1	8
2	12-PHY-BIPTP2#	Theoretical Physics 2 - Electrodynamics 1	8
2	12-PHY-BIPTP4	Theoretical Physics 4 - Quantum Mechanics	8
1/3	12-PHY-BIPTP5	Theoretical Physics 5 - Statistical Physics	8
or 1 Module from the (German) Bachelor Program "B.Sc. Physik":			
1/3	12-PHY-BPEP3*	Experimentalphysik 3 - Optik und Quantenphysik	8
2	12-PHY-BPEP4*	Experimentalphysik 4 - Struktur der Materie	8
1/3	12-PHY-BEP5*	Experimentalphysik 5 - Festkörperphysik	8
1/3	12-PHY-BTP1*	Theoretische Physik 1 - Theoretische Mechanik	8
2	12-PHY-BTP2*	Theoretische Physik 2 - Quantenmechanik	8
1/3	12-PHY-BTP3*	Theoretische Physik 3 - Statistische Physik	8
2	12-PHY-BTP4*	Theoretische Physik 4 - Elektrodynamik & klassische Feldtheorie	8
1 – 3		***Free Elective Area***	***10***
1 – 3		either 2 modules from the Elective Areas in Meteorology or any module(s) from other study programs§,*	10

Cooperation agreements exist with the Institute for Geography for the following modules:			
1/3	12-GGR-B-PG01A	Grundlagen der Physischen Geographie/Geoökologie I: Gestein, Relief, Boden	5
1/3	12-GGR-B-PG01B	Grundlagen der Physischen Geographie/Geoökologie II: Klima, Wasser, Vegetation	5
2	12-GGR-B-PG02	Geosystemanalyse, Methoden und Bewertung$	10
2	12-GGR-B-GF04	Grundlagen der Fernerkundung	5
1/3	12-GGR-B-GF05	Einführung in die Geoinformatik	10
1/3	12-GGR-M-PG02	Umweltbezogene Geoökologische Standortbewertung	5
1/3	12-GGR-M-PG06	Angewandte Spezialgebiete der Geographie	10
1/3	12-GGR-M-GFP1	Umweltfernerkundung$	5
2	12-GGR-M-GFP2	Geographische Informationssysteme- Modelle und Analysen$	5
		Total	**48**

* Lectures and examinations (might be) in German language

Students, who have already completed the module "Mathematische Methoden - Methoden der klassischen Physik" (12-PHY-BMAME1) in the Bachelor's program cannot select these modules.

§ Any module(s) offered in other study programs can be chosen according to valid cooperation agreements. Further modules can be approved by the examination board upon request.

$ Please check the participation requirements in the module descriptions.

2 Module Descriptions

2.1 Compulsory Area – Meteorology

Module title			Module number	ECTS
P1 – Dynamics and Synoptics			**12-111-1001**	**6 CP**
Responsibility: Professorship for Theoretical Meteorology				
Module type: compulsory	Recommended for: 1st semester	Module availability: every winter semester	Applicability: - M.Sc. Meteorology	
Workload: 180 h	Tutorial hours: 60 h	Private study hours: 120 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours): - Lecture "Dynamics and Synoptics" (2 CHW / 30 h / 60 h) - Exercise "Dynamics and Synoptics" (2 CHW / 30 h / 60 h)				
Participation requirements: None				
Examinations (duration; weighting) and pre-examination requirements: Oral examination (45 min; weighting x1)				

Objectives	After active participation in the module, students are able to understand the theoretical principles of dynamic meteorology and to apply them in practical analysis and weather forecasting. They are able to independently apply this knowledge to current questions of synoptic weather forecasting and to link selected situations of large-scale weather with theoretical methods. The students are able to evaluate the weather forecasts and to present these both in written and oral form.
Content	The lecture "Dynamics and Synoptics" deals with the kinematics of temperature and wind as well as the dynamics of air density, pressure and wind. This includes different equilibrium wind systems, the dynamic stability, the ageostrophic horizontal wind, and temperature advection. Especially the vortex dynamics, frontal zone, pressure systems, and the primitive equations will be covered. The exercise "Dynamics and Synoptics" practices the answering of concrete synoptic questions by means of numerical, analytical or statistical methods, their discussion and the preparation to present the results.
References	- Bott, A., 2012: Synoptische Meteorologie: Methoden der Wetteranalyse und –prognose. Cambridge University Press, London, 486 pp. - Holton, J. R., 2004: An Introduction to Dynamic Meteorology. 4th Edition, Elsevier Academic Press, San Diego, California, 535 pp.

Module title			Module number	ECTS
P2 – Atmospheric Radiation			**12-111-1019**	**5 CP**
Responsibility Professorship for Mesoscale Processes and Numerical Weather Forcast				
Module type compulsory	Recommended for 1st semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture "Atmospheric Radiation" (2 CHW / 30 h / 60 h) - Exercise "Atmospheric Radiation" (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Written exam (90 min; weighting ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*				

Objectives	After active participation in the module, students are able to understand the basics of atmospheric radiative transfer. They are able to independently apply this knowledge to current research questions of the atmospheric radiative energy budget in cloudy and cloudless conditions, the passive solar remote sensing and are able to synthesize related results. Some of the concepts discussed in the lecture have a high degree of abstraction, which is intended to promote abstract thinking. The students are able to evaluate their gained knowledge and to present this both in written and oral form.
Content	The lecture "Atmospheric Radiation" deals with basic definitions of radiative quantities, the interaction of atmospheric radiation with individual particles, volumetric optical properties, and the radiation transfer equation. The exercise "Atmospheric Radiation" practices the answering of concrete questions by means of numerical, analytical or statistical methods, their discussion, and the presentation of the results.
References	- Wendisch, M., and Yang, P., 2012: Theory of Atmospheric Radiative Transfer. Wiley-VCH, 366 pp. - Petty, G. W., 2006: A First Course in Atmospheric Radiation. Sundog Publishing, Madison, Wisconsin, 459 pp.

Module title	Module number	ECTS
P3 – Advanced Weather Discussions	**12-111-1020**	**5 CP**

Responsibility
Professorship for Mesoscale Processes and Numerical Weather Forcast

Module type	Recommended for	Module availability	Applicability
compulsory	2nd semester	every summer semester	- M.Sc. Meteorology
Workload	**Tutorial hours**	**Private study hours**	
150 h	45 h	105 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Advanced Weather Discussions” (2 CHW / 30 h / 60 h) - Exercise “Advanced Weather Discussions” (1 CHW / 15 h / 45 h)

Participation requirements
Participitation in modul 12-111-1001 "P1 - Dynamics and Synoptics"

Examinations (duration; weighting) and pre-examination requirements
Oral presentation (45 min; weighting ×1) *Pre-examination requirements: Weekly exercises to prepare weather projection for different locations. Points are awarded for the projections. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the examination.*

Objectives	After active participation in the module, students are able to compile weather forecasts on the basis of theoretical methods and procedures and to critically evaluate their quality. They able to independently apply this knowledge to current questions of synoptic weather forecasting. The students are able to make a critical evaluation of available meteorological data. By interpreting these complex data, they can prepare a weather forecast and present it in oral form.
Content	The seminar "Advanced Weather Discussions" covers methods for the interpretation of complex weather data and the preparation of weather forecasts based on observation data and synoptic principles. In the exercise, students prepare and present a full weather briefing for choosen locations. The projection and forecasts products of the numerical weather models are critically evaluated and presented.
References	- Kraus, H., 2004: Die Atmosphäre der Erde. 3. Auflage. Springer, Berlin, Heidelberg. 422 pp. - Kurz, H., 1990: Synoptische Meteorologie. Leitfäden für die Ausbildung im Deutschen Wetterdienst, Nr. 8. 3. Auflage. Selbstverlag des Deutschen Wetterdienstes, Offenbach. 197 pp.

Module title			Module number	ECTS
P4 – Dynamics of the Global Climate System			**12-111-1021**	**6 CP**
Responsibility Professorship for Theoretical Meteorology				
Module type compulsory	Recommended for 2^{nd} semester	Module availability every summer semester	Applicability - M.Sc. Meteorology	
Workload 180 h	Tutorial hours 60 h	Private study hours 120 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture "Dynamics of the Global Climate System" (2 CHW / 30 h / 60 h) - Exercise "Dynamics of the Global Climate System" (2 CHW / 30 h / 60 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral exam (30 min; weighting ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*				

Objectives	After active participation in the module, students are able to understand the large- and mesoscale atmospheric and oceanic circulation. They are able to independently apply this knowledge to current research questions of climate dynamics and to synthesize related results. The students are able to evaluate thier findings and conclusions and present them both in written and oral form.
Content	The lecture "Dynamics of the Global Climate System" deals with different modes of the large-scale atmospheric circulation, modes of large-scale oceanic circulation, atmosphere-ocean interactions, tropical cyclones, and organized convection. The exercise "Dynamics of the Global Climate System" includes the analysis of concrete climate data sets for a deeper understanding of climate dynamics and the practical application of methods which were learned in the lecture.
References	- Peixoto und Oort, Physics of Climate, Springer, 2007, 564 pp. - Holton, An Introduction to Dynamic Meteorology, Elsevier Academic Press, 2004, 535 pp.

<table>
<tr><td colspan="3">Module title
P5 – Current Research in Meteorology</td><td>Module number
12-111-1022</td><td>ECTS
10 CP</td></tr>
<tr><td colspan="5">Responsibility
Director of the Leipzig Institute for Meteorology</td></tr>
<tr><td>Module type
compulsory</td><td>Recommended for
3rd semester</td><td>Module availability
every winter semester</td><td colspan="2" rowspan="2">Applicability
- M.Sc. Meteorology</td></tr>
<tr><td>Workload
300 h</td><td>Tutorial hours
45 h</td><td>Private study hours
255 h</td></tr>
<tr><td colspan="5">Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Current Research in Meteorology” (1 CHW / 15 h / 45 h)
- Seminar “Current Research in Meteorology” (2 CHW / 30 h / 210 h)</td></tr>
<tr><td colspan="5">Participation requirements
Participation in Modules 12-111-1001, 12-111-1019, 12-111-1020, 12-111-1021 is recommended</td></tr>
<tr><td colspan="5">Examinations (duration; weighting) and pre-examination requirements
Oral presentation (45 min; weighting ×1)</td></tr>
<tr><td>**Objectives**</td><td colspan="4">After active participation in the module, students are able to understand the current state of knowledge in a special field of meteorology. They obtain an overview of current research areas. They are able to conduct an independent and comprehensive literature search. The students are able to evaluate the collected findings and present these both in written and oral form.</td></tr>
<tr><td>**Content**</td><td colspan="4">In the lecture "Current Research in Meteorology" a comprehensive overview of the state of the art of research in key areas of meteorology is given. The seminar "Current Research in Meteorology" includes methods of literature work. It requires the familiarization with the state of art in a special research field and its presentation and discussion. The seminar also includes the participation in scientific discussions on this special field within a working group of the Institute of Meteorology and its research partners.</td></tr>
<tr><td>**References**</td><td colspan="4">none</td></tr>
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Module title			Module number	ECTS
P6 – Advanced Scientific Working in Meteorology			**12-111-1023**	**10 CP**
Responsibility Director of the Leipzig Institute for Meteorology				
Module type compulsory	Recommended for 3rd semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 300 h	Tutorial hours 45 h	Private study hours 255 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Advanced Scientific Working in Meteorology” (1 CHW / 15 h / 45 h) - Seminar “Advanced Scientific Working in Meteorology” (2 CHW / 30 h / 210 h)				
Participation requirements Participation in Modules 12-111-1001, 12-111-1019, 12-111-1020, 12-111-1021 is recommended				
Examinations (duration; weighting) and pre-examination requirements Written report (12 weeks; weighting ×1)				

Objectives	With the active participation in the module, students gain the ability to start working in a meteorological research area and applying its working methods in an effective and comprehencive way. They gain knowledge about state of the art experimental and theoretical-mathematical methods. After active participation in the module, students are able to understand the essential meteorological working methods. They are able to independently apply this knowledge to current research questions and to synthesize related results. The students are able to evaluate their findings and to present these both in written and oral form for an open discission.
Content	The lecture "Advanced Scientific Working in Meteorology" provides a comprehensive overview of experimental and theoretical working methods in meteorology. The seminar "Advanced Scientific Working in Meteorology" includes the familiarization with the methods of a special research field, intensive discussion of these methods and participation in scientific discussions on this special field within a working group of the Institute for meteorology and its research partners.
References	none

2.2 Elective Area – General Meteorology

Module title			Module number	ECTS
A1 – Atmospheric Aerosol			**12-111-1024**	**5 CP**
Responsibility Professorship for Atmospheric Physics				
Module type elective	Recommended for 1st/3rd semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Atmospheric Aerosol” (2 CHW / 30 h / 60 h) - Exercise “Atmospheric Aerosol” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Written exam (60 min; weighting ×1)				

Objectives	After active participation in the module, students are able to understand the fundamentals of physical measurements of atmospheric aerosol particles. They are able to independently apply this knowledge to relevant and and research-related measuring techniques for atmospheric aerosol and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Atmospheric Aerosol" first deals with the fundamental basics of aerosol physics. Based on this, the most important measurement methods and instruments will be interactively introduced, so that a deeper understanding of their application is gained. In the seminar "Atmospheric Aerosol" current results from scientific publication on the physical characterisation of atmospheric aerosol particles are elaborated, presented, and discussed.
References	- W. Hinds: Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles: Properties, Behaviour and Measurement of Airborne Particles - P. Baron: Aerosol Measurement: Principles, Techniques, and Applications

Module title			Module number	ECTS
A2 – Atmospheric Chemistry - The Multiphase System			**12-111-1025**	**5 CP**
Responsibility Professorship for Atmospheric Chemistry				
Module type elective	Recommended for $1^{st}/3^{rd}$ semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 60 h	Private study hours 90 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Atmospheric Chemistry - The Multiphase System” (2 CHW / 30 h / 45 h) - Exercise “Atmospheric Chemistry - The Multiphase System” (1 CHW / 15 h / 30 h) - Seminar “Atmospheric Chemistry” (1 CHW / 15 h / 15 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Written exam (90 min; weighting ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*				
Objectives	After active participation in the module, students are able to understand the extended basics of atmospheric chemistry. They are able to independently apply this knowledge to current research questions of atmospheric chemistry and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.			
Content	In the lecture "Atmospheric Chemistry - The Multiphase System" the chemistry of the troposphere and stratosphere are discussed in detail. The role of particles in the atmospheric multiphase system is elaborated. The budgets of tropospheric particles and the state of knowledge on chemical reactions on and in aerosol particles, cloud droplets, rain dropleds, and fog particles in the troposphere are presented in a comprehensive way. The current status of model developments for understanding tropospheric multiphase systems is presented and mediated. In the exercise "Atmospheric Chemistry - The Multiphase System” laboratory methods for atmospheric chemistry are trained on the basis of concrete experiments. In the seminar "Atmospheric Chemistry" the results and findings of the experiments are presented and discussed.			
References	- Wayne, R. P., 2000: Chemistry of Atmospheres, an introduction to the chemistry of the atmospheres of earth, the planets, and their satellites. Oxford: Oxford Univ. Press. - Seinfeld, J. H. und Pandis, S. N., 1998: Atmospheric Chemistry and Physics, From Air Pollution to Climate Change. New York: Wiley. - Finlayson-Pitts, B. J. und Pitts, J. N., 1998: Atmospheric Chemistry. New York, Wiley.			

<table>
<tr><td colspan="3">Module title
A3 – Numerical Weather Prediction and Climate Modelling</td><td>Module number
12-111-1026</td><td>ECTS
5 CP</td></tr>
<tr><td colspan="5">Responsibility
Professorship for Theoretical Meteorology</td></tr>
<tr><td>Module type
elective</td><td>Recommended for
1st/3rd semester</td><td>Module availability
every winter semester</td><td colspan="2" rowspan="2">Applicability
- M.Sc. Meteorology</td></tr>
<tr><td>Workload
150 h</td><td>Tutorial hours
60 h</td><td>Private study hours
90 h</td></tr>
<tr><td colspan="5">Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Numerical Weather Prediction and Climate Modelling” (2 CHW / 30 h / 60 h)
- Practical Course “Numerical Weather Prediction and Climate Modelling” (2 CHW / 15 h / 45 h)</td></tr>
<tr><td colspan="5">Participation requirements
None</td></tr>
<tr><td colspan="5">Examinations (duration; weighting) and pre-examination requirements
Oral presentation (45 min) and written report (4 weeks); weighting ×1</td></tr>
<tr><td>**Objectives**</td><td colspan="4">After active participation in the module, students are able to understand the basics of numerical weather predictions and climate simulations. They are able to independently apply this knowledge to current research questions of weather forecasting and climate change and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.</td></tr>
<tr><td>**Content**</td><td colspan="4">The lecture "Numerical Weather Prediction and Climate Modelling" gives a detailed introduction to complex weather forecast and climate models and their applications. Various parameterizations e.g. of turbulence and cloud processes are discussed. In the practical course "Numerical Weather Prediction and Climate Modelling” the students will perform studies on climate-relevant processes with a global atmosphere model. A numerical regional weather forecast will be prepared with a mesoscale weather forecast model.</td></tr>
<tr><td>**References**</td><td colspan="4">- Trenberth, Climate System Modeling, Cambridge University Press, 2010, 820 pp.
- Kalnay, Atmospheric Modeling, Data Assmilation and Predictability, Cambridge University Press, 2003, 341 pp.</td></tr>
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Module title **A4 – Polar Climate**			Module number **12-111-1043**	ECTS **5 CP**
Responsibility Junior-Professorship for the Arctic System				
Module type elective	Recommended for 2nd semester	Module availability every summer semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Polar Climate” (2 CHW / 30 h / 60 h) - Exercise “Polar Climate” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min; weighting ×1)				

Objectives	After active participation in the module, students are able to understand the basics of the climate in high latitudes. They are able to independently apply this knowledge to current research questions of the Arctic and Antarctic climate system and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Polar Climate" comprehensively discusses the components of the Arctic climate system including atmosphere, ocean and sea ice and their interaction through energy fluxes and the hydrological cycle. The students learn about the large-scale circulation in the Arctic and the Arctic Amplification. The characteristics of the Arctic and Antarctic climate systems are compared. In the exercise "Polar Climate" selected questions on the Arctic / Antarctic climate system are discussed on the basis of current observations and numerical simulations. The results are presented and discussed in detail. In addition, social aspects of the relevance of the Arctic amplification are elaborated.
References	- Serreze, M. and Barry, R.: The Arctic Climate System, Cambridge University Press - Tomczak, M. and Godfrey, J.S.: Regional Oceanography (Ch.7 Arctic Oceanography), Daya Publishing House

Module title			Module number	ECTS
A5 – Cloud Physics			**12-111-1028**	**5 CP**
Responsibility: Professorship for Atmospheric Physics				
Module type: elective	Recommended for: 2nd semester	Module availability: every summer semester	Applicability: - M.Sc. Meteorology	
Workload: 150 h	Tutorial hours: 45 h	Private study hours: 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours): - Lecture “Cloud Physics” (2 CHW / 30 h / 60 h) - Exercise “Cloud Physics” (1 CHW / 15 h / 45 h)				
Participation requirements: None				
Examinations (duration; weighting) and pre-examination requirements: Written exam (60 min; weighting ×1)				

Objectives	After active participation in the module, students obtain a basic understanding of the fundamental dynamic, thermodynamic and and microphysical cloud processes, both in theory and practice. They are able to independently apply this knowledge to current research questions of cloud physics and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	In the lecture "Cloud Physics" the following topics are discussed comprehensively: thermodynamics of multiphase/multi-component systems, hygroscopic growth, cloud drop activation, dynamic growth through condensation and collision/coalescence, cloud drop freezing, cloud dynamics. In the exercise "Cloud Physics", the theory and methods given in the lecture are applied to concrete examples.
References	- Pruppacher, H. R. und Klett, J. D., 1997. Microphysics of clouds and precipitation. Kluver Academic Publishers.

Module title **A6 – Dust in the Atmosphere**			Module number **12-111-1042**	ECTS **5 CP**
Responsibility Professorship for Modelling Atmospheric Processes				
Module type elective	Recommended for 1st/3rd semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Dust in the Atmosphere” (2 CHW / 30 h / 60 h) - Seminar “Dust in the Atmosphere” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min) and written report (4 weeks); weighting ×1				

Objectives	After active participation in the module, students are able to understand the basics of the life cycle of atmospheric dust particles. They are able to independently apply this knowledge to current research questions of dust transport and its impacts on the atmosphere and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Dust in the Atmosphere" comprehensively discusses the special features of the atmospheric dust life cycle. This includes dust sources and dust emissions into the boundary layer, dust transport, and deposition processes. Further, the meteorology of desert regions and its interactions with dust particles are covered. In addition, social aspects of the regional and global mineral dust distribution are discussed. In the seminar "Dust in the Atmosphere" selected questions on atmospheric dust cycle are answered on the basis of current observations and numerical simulations. The results are presented and are discussed in detail.
References	- T. Warner, Desert Meteorology, Cambridge Univ. Press, 2004 - P. Knippertz, J.-B. Stuut, Mineral Dust, Springer, 2014

Module title			Module number	ECTS
A7 – Atmospheric Trace Substances and their Modelling			**12-111-1041**	**5 CP**
Responsibility Professorship for Modelling Atmospheric Processes				
Module type elective	Recommended for 1st/3rd semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Atmospheric Trace Substances and their Modelling” (2 CHW / 30 h / 60 h) - Seminar “Atmospheric Trace Substances and their Modelling” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min) and written report (4 weeks); weighting ×1				
Objectives	After active participation in the module, students are able to understand the fundamentals of processes that determine the distribution of important atmospheric trace substances. The studends know how these processes are described in transport models and how these models are applied in air quality and climate studies. They are able to independently apply this knowledge to current research questions of atmospheric trace substances and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.			
Content	The lecture "Atmospheric Trace Substances and their Modelling" deals with the atmospheric composition, the description of chemical and physical processes of trace substances in atmospheric models, the interaction of trace substances with radiation and clouds, and fundamentals and examples of chemical transport models. The seminar "Atmospheric Trace Substances and their Modelling" deepens the knowledge and scientific questions of the lecture by seminar lectures on individual topics that are elaborated by the students			
References	- J. Seinfeld, und S. Pandis, Atmospheric Chemistry and Physics, From Air Pollution to Climate Change. New York: Wiley., 1998 - M.Z. Jacobson, Fundamentals of Atmospheric Modeling, Cambridge University Press, 2005			

2.3 Elective Area – Experimental Meteorology

Module title			Module number	ECTS
E1 – Airborne Physical Measuring Methods			**12-111-1035**	**5 CP**

Responsibility
Professorship for Mesoscale Processes and Numerical Weather Forcast

Module type	Recommended for	Module availability	Applicability
elective	$1^{st}/3^{rd}$ semester	every winter semester	- M.Sc. Meteorology
Workload	**Tutorial hours**	**Private study hours**	
150 h	60 h	90 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)

- Lecture “Airborne Physical Measuring Methods” (2 CHW / 30 h / 45 h)
- Practical Course “Airborne Physical Measuring Methods” (2 CHW / 30 h / 45 h)

Participation requirements

None

Examinations (duration; weighting) and pre-examination requirements

Written reports for the experiments of the practical course (4 weeks; weighting ×1)

Objectives	After active participation in the module, students are able to understand the basics of airborne measurements of atmospheric properties. They are able to independently apply this knowledge to current measurement methods for meteorological quantities, microphysical parameter, and atmosperic radiative quantities and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Airborne Physical Measuring Methods" covers the measurement of basic meteorological parameters on moving measuring platforms. Special measurement instruments for the quantification of atmospheric radiation, the characterization of cloud, precipitation and aerosol particles are introduced. In the practical course "Airborne Physical Measuring Methods" the students perform and analyse own concrete measurements which are typicall applied on moving platforms. The measurement data are processed by means of numerical, analytical or statistical methods are evaluated, discussed and presented.
References	- Wendisch, M.(Editor), and Brenguier, J.-L. (Hrsg.), 2013: Airborne Measurements for Environmental Research: Methods and Instruments. Wiley-VCH, 641 pp.

Module title **E2 – Ground-based Radar and Microwave Remote Sensing**			Module number **12-111-1036**	ECTS **5 CP**
Responsibility Junior-Professorship for the Arctic System				
Module type elective	Recommended for 1st/3rd semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Remote Sensing of the Atmosphere with Radar and Microwave Radiometer” (2 CHW / 30 h / 60 h) - Exercise “Microwave Remote Sensing” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral exam (30 min; weighting ×1) *Pre-examination requirements: Written report of the experiments of the exercise (4 weeks).*				

Objectives	After active participation in the module, students are able to understand the fundamentals of ground-based remote sensing techniques of the atmosphere with microwave radiation. They are able to independently apply this knowledge to current research questions and data of microwave remote sensing of the atmosphere and are able to synthesize related results. They understand the link between cloud microphysical properties and remote sensing observations. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Remote Sensing of the Atmosphere with Radar and Microwave Radiometer" comprehensively discusses active and passive methods in the field of radar and microwave radiometer remote sensing and their applications for quantifying atmospheric state parameters as well as cloud and precipitation properties. In the exercise "Microwave Remote Sensing” the relationships between meteorological parameters of the atmosphere and active and passive observations in the microwave range is elaborated on the basis of experiments using the methods given in the lecture.
References	- Cimini, D.: Integrated Ground-Based Observing Systems, 2011, Springer - Fabry, F.: Radar Meteorology, 2015, Cambridge University Press - Rinehart, R.E.: Radar for Meteorologists, 1997. Rinehart Publishing

Module title			Module number	ECTS
E3 – Upper Atmosphere			**12-111-1037**	**5 CP**
Responsibility: Professorship for Higher Atmosphere Dynamics				
Module type: elective	Recommended for: 2^{nd} semester	Module availability: every summer semester	Applicability: - M.Sc. Meteorology	
Workload: 150 h	Tutorial hours: 60 h	Private study hours: 90 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours): - Lecture “Upper Atmosphere” (2 CHW / 30 h / 60 h) - Practical Course “Measurements in the Upper Atmosphere” (2 CHW / 30 h / 30 h)				
Participation requirements: None				
Examinations (duration; weighting) and pre-examination requirements: Oral presentation (45 min) and written report (4 weeks); weighting ×1				
Objectives	After active participation in the module, students are able to understand the basics of upper atmosphere physics. They know the structure of the upper atmosphere, the essential processes in the upper atmosphere, and the most important measurement methods applied to obtain data from the upper atmosphere. They are able to independently apply this knowledge to current research questions of the upper atmosphere and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.			
Content	The lecture "Upper Atmosphere" comprahensivly discusses the composition and dynamics of the neutral thermosphere, the structure of the ionosphere and plasma sphere, the description of the magnetic field of the earth, and measurement methods for the neutral and ionised upper atmosphere. In the practical course "Measurements in the Upper Atmosphere" current measurements of the dynamics of the upper atmosphere are evaluated, discussed and presented.			
References	- Prölls, G.W.: Physik des erdnahen Weltraums, Springer, 2001. - Campbell, W.H.: Introduction to Geomagnetic Fields, Cambridge University Press, 1997.			

Module title			Module number	ECTS
E4 – Active Remote Sensing with Lidar			**12-111-1038**	**5 CP**
Responsibility: Professorship for Atmospheric Physics				
Module type: elective	Recommended for: 1st/3rd semester	Module availability: every winter semester	Applicability: - M.Sc. Meteorology	
Workload: 150 h	Tutorial hours: 45 h	Private study hours: 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Active Remote Sensing with Lidar” (2 CHW / 30 h / 60 h) - Seminar “Active Remote Sensing with Lidar” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min) and written report (4 weeks); weighting ×1				

Objectives	After active participation in the module, students are able to understand the fundamentals of ground-based remote sensing techniques of the atmosphere which are based on optical methods. They are able to independently apply this knowledge to current research questions and data of lidar remote sensing of the atmosphere and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Active Remote Sensing with Lidar" comprehensively discusses active and passive methods with emphasis on lidar remote sensing and their application for characterizing atmospheric state parameters and properties of aerosol and cloud particles. The seminar "Active Remote Sensing with Lidar" studies recent publications that apply optical remote sensing methods in the atmosphere. Concrete questions and resutls are presented and discussed.
References	- Weitkamp, Claus (Ed.): Lidar Range-Resolved Optical Remote Sensing of the Atmosphere, Springer Series in Optical Sciences, Vol. 102, 2005, ISBN: 978-0-387-40075-4. - European Cooperation in Science and Technology: Integrated Ground-Based Remote-Sensing Stations for Atmospheric Profiling, COST Action 720, EUR 24172, ISBN 978-92-898-0050-1, doi:10.2831/10752

Module title **E5 – Spaceborne Remote Sensing**			Module number **12-111-1039**	ECTS **5 CP**
Responsibility Professorship for Atmospheric Physic				
Module type elective	Recommended for 2nd semester	Module availability every summer semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture "Spaceborne Remote Sensing" (2 CHW / 30 h / 60 h) - Exercise "Spaceborne Remote Sensing" (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Written exam (60 min; weighting ×1)				

Objectives	After active participation in the module, students have a basic understanding of the retrieval of atmospheric parameters using satellite observations of reflected solar and emitted thermal radiation. They are able to independently apply this knowledge to current research questions of satellite remote sensing and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	In the lecture "Spaceborne Remote Sensing" the following topics are comprehensively discussed: principles of remote sensing and its application in different fields of research, satellite orbits, radiative transfer theory and solution methods, vertical profiling using radiation in the thermal spectral range, retrieval of cloud and aerosol properties from spectral and spatial patterns, radar and lidar remote sensing from space. In the Exercise "Spaceborne Remote Sensing" the theory and methods given in the lecture are explored using concrete examples and data sets. The results are presented and discussed.
References	- SQ Kidder and TH Vonder Haar: Satellite Meteorology, Academic Press 1995

2.4 Elective Area – Theoretical Meteorology

Module title			Module number	ECTS
T1 – Dynamics of the Middle Atmosphere			**12-111-1029**	**5 CP**
Responsibility Professorship for Higher Atmosphere Dynamics				
Module type elective	Recommended for $1^{st}/3^{rd}$ semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture "Dynamics of the Middle Atmosphere" (2 CHW / 30 h / 60 h) - Exercise "Dynamics of the Middle Atmosphere" (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min) and written report (4 weeks); weighting ×1				

Objectives	After active participation in the module, students are able to understand the basics of the dynamics of the middle atmosphere. They are able to independently apply this knowledge to current research questions of the middle atmosphere and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Dynamics of the Middle Atmosphere" deals with the climatology and dynamics of the stratosphere and mesosphere, primitive equations, the quasi-geostrophic equations, linear wave theory, tides, planetary waves, the zonal averaged equations, TEM-equations, and gravity waves in the middle atmosphere. The exercise "Dynamics of the Middle Atmosphere" practices the answering of concrete question with numerical, analytical or statistical methods, their discussion, and the presentation of the results.
References	- Andrews, D.G., J.R. Holton, C.B. Leovy: Middle Atmosphere Dynamics, Academic Press, 1987. - Brasseur, G., S. Solomon: Aeronomy of the Middle Atmosphere, D. Reidel, 1986.

Module title				Module number	ECTS
T2 – Atmospheric Models: Parameterizations and Scales				**12-111-1031**	**5 CP**
Responsibility Professorship for Modelling Atmospheric Processes					
Module type elective	Recommended for 2nd semester	Module availability every summer semester	Applicability - M.Sc. Meteorology		
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h			
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Atmospheric Models: Parameterizations and Scales” (2 CHW / 30 h / 60 h) - Practical Course “Atmospheric Models: Parameterizations and Scales” (1 CHW / 15 h / 45 h)					
Participation requirements None					
Examinations (duration; weighting) and pre-examination requirements Written Exam (60 min; weighting ×1)					
Objectives	After active participation in the module, students are able to understand the basics of parameterizations and scale ranges of atmospheric models. They are able to independently apply this knowledge to current research questions of atmospheric modeling and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.				
Content	The lecture "Atmospheric Models: Parameterizations and Scales" covers the basic equations for air movement and atmospheric transport, scales of atmospheric processes with focus on the mesoscale, scale analysis, approximations and parameterizations, such as the parameterization of subscale and physical processes including turbulence, convection, processes of trace substances. In the practical course "Atmospheric Models: Parameterizations and Scales" the students analyze concrete examples of model results to discuss and present the effects of different scales and parameterizations on the model results.				
References	- D.J. Stensrud: Parameterization Schemes: Keys to Understanding Numerical Weather Prediction Models, Cambridge University Press, 2010 - T. Warner: Numerical Weather and Climate Prediction, Cambridge University Press, 2010 - R. Pielke: Mesoscale Meteorological Modeling, Academic Press, 2002.				

Module title			Module number	ECTS
T3 – Radiative Transfer Lab			**12-111-1040**	**5 CP**
Responsibility Director of the Leipzig Institute for Meteorology				
Module type elective	Recommended for 2^{nd} semester	Module availability every summer semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Radiative Transfer Lab” (1 CHW / 15 h / 45 h) - Practical Course “Radiative Transfer Lab” (2 CHW / 30 h / 60 h)				
Participation requirements Participation in Modul 12-111-1019 "P2 - Atmospheric Radiation"				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min) and written report (4 weeks); weighting ×1				
Objectives	After active participation in the module, students are able to understand the basics of radiative transfer simulations. They are able to independently apply this knowledge to current research questions of atmospheric radiation and remote sensing and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.			
Content	The lecture "Radiative Transfer Lab" discusses the composition of different model atmospheres, solar and thermal source terms, wavelength dependent absorption properties of relevant trace gases, scatter and extinction properties of the clear atmosphere and of aerosol and cloud particles, numerical methods for the solution of radiative transfer equation. In the practical course "Radiative Transfer Lab" the students perform experiements with raditive transfer models to analyze, present and discuss the effect the atmosphere on the radiative transfer. Therefore, the students will be trained in basic computers skills (Linux) and programming (Fortran, Python) with application to radiative transfer and line-for-line simulation of transmission.			
References	- Liou, K.-N., 2002: An Introduction to Atmospheric Radiation, 2nd Edition, Academic Press, 2002. - Zdunkowski, W., T. Trautmann, and A. Bott, 2007: Radiation in the Atmosphere. A Course in Theoretical Meteorology. Cambridge University Press, 2007.			

Module title **T4 – Scattering and Atmospheric Optics**			Module number **12-111-1032**	ECTS **5 CP**
Responsibility Professorship for Atmospheric Physics				
Module type elective	Recommended for 1st/3rd semester	Module availability every winter semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 45 h	Private study hours 105 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Scattering and Atmospheric Optics” (2 CHW / 30 h / 60 h) - Seminar “Applied Scattering Theory” (1 CHW / 15 h / 45 h)				
Participation requirements None				
Examinations (duration; weighting) and pre-examination requirements Oral presentation (45 min) and written report (4 weeks); weighting ×1				

Objectives	After active participation in the module, students are able to understand the basics of optics of the atmosphere and various scattering theories to describe the interaction of light with particles. They are able to independently apply this knowledge to current questions of atmospheric research with focus on radiation and remote sensing and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.
Content	The lecture "Scattering and Atmospheric Optics" discusses the development, propagation and perception of light, a diversity of optical phenomena in the atmosphere, sky and cloud colours, the basic principles of scattering theory, Mie and Rayleigh scattering and scattering theories for non-spherical scattering particles and their applications in the atmospheric optics. In the seminar "Applied Scattering Theory" the students present and discuss concrete topics of atmospheric optics on the basis of current literature. Numerical tools modelling the optical scattering are applied to answer concrete questions linked to the scattering theory.
References	- Bohren, C.F., D.R. Huffman: Absorption and Scattering of Light by Small Particles, John Wiley & Sons, 1998 - Mishchenko, M.I., Hovenier, J.W., Travis, L.D., Light Scattering by Nonspherical Particles, Academic Press, 2000.

Module title			Module number	ECTS
T5 – Terrestrial Radiative Transfer			**12-111-1033**	**5 CP**
Responsibility Professorship for Mesoscale Processes and Numerical Weather Forcast				
Module type elective	Recommended for 2^{nd} semester	Module availability every summer semester	Applicability - M.Sc. Meteorology	
Workload 150 h	Tutorial hours 60 h	Private study hours 90 h		
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Terrestrial Radiative Transfer” (2 CHW / 30 h / 45 h) - Practical Course “Terrestrial Radiative Transfer” (2 CHW / 30 h / 45 h)				
Participation requirements Participation in Module 12-111-1019 "P2 - Atmospheric Radiation"				
Examinations (duration; weighting) and pre-examination requirements Written reports for the experiments of the practival course (4 weeks; weighting ×1)				
Objectives	After active participation in the module, students are able to understand the basics of the terrestrial radiative transfer in the atmosphere. They are able to independently apply this knowledge to current research questions of the atmospheric radiative budget in cloudy and non-cloudy conditions, and passive terrestrial remote sensing and are able to synthesize related results. Some of the concepts discussed in the lecture have a high degree of abstraction, which is intended to promote abstract thinking. The students are able to evaluate their findings and to present this both in written and oral form.			
Content	The lecture "Terrestrial Radiative Transfer" discusses the terrestrial radiative transfer equation, its application to spectral and broadband radiance and radiative flux densities. In particular the absorption and emission by atmospheric gases is studied. In the practical course "Terrestrial Radiative Transfer" the students answer concrete questions by means of numerical, analytical or statistical methods, their discussion, and the written presentation of the results.			
References	- Goody, R.M., and Y.L. Yung, 1989: Atmospheric radiation – Theoretical Basis. Oxford University Press, 519 pp. - Houghton, J.T., and S.D. Smith, 1966: Infrared Physics. Oxford University Press, 319 pp.			

Module title	Module number	ECTS
T6 – Data Assimilation	**12-111-1034**	**5 CP**

Responsibility
Professorship for Theoretical Meteorology

Module type	Recommended for	Module availability	Applicability
elective	2nd semester	every summer semester	- M.Sc. Meteorology
Workload	**Tutorial hours**	**Private study hours**	
150 h	45 h	105 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Data Assimilation” (2 CHW / 30 h / 60 h)
- Practical Course “Data Assimilation” (1 CHW / 15 h / 45 h)

Participation requirements
Participation in Modul 12-111-1026 "A3 – Numerical Weather Prediction and Climate Modelling" is recommended

Examinations (duration; weighting) and pre-examination requirements
Oral presentation (45 min) and written report for the experiments of the practical course (4 weeks); weighting ×1

Objectives

After active participation in the module, students are able to understand the basics of data assimilation methods. They are able to independently apply this knowledge to assimilate data into numerical atmospheric models and are able to synthesize related results. The students are able to evaluate their findings and to present this both in written and oral form.

Content

The lecture "Data Assimilation" discusses the combination of modeling and observations by forward operators for remote sensing, nudging, variational methods, and Kalman filters. In the practical course "Data Assimilation" the students transfer their knowlegde into a numerical modell, which is used to perform independent sensitivity studies on data assimilation. These results are presented and discussed.

References

- Evensen, Data Assimilation, Springer, 2009, 307 pp.
- Kalnay, Atmospheric Modeling, Data Assmilation and Predictability, Cambridge University Press, 2003, 341 pp.

2.5 Elective Area – Physics

Modules from the English Bachelor program "B.Sc. IPSP"

Module title	Module number
Experimental Physics 3 - Electromagnetic Waves and Foundations of Quantum Physics	**12-PHY-BIEP3**
Module title (German) **Experimentalphysik 3 - Elektromagnetische Wellen und Grundlagen der Quantenphysik**	ECTS **8 CP**

Responsibility
Director of the Peter Debye Institute for Soft Matter Physics / Director of the Felix Bloch Institute for Solid State Physics

Module type	Recommended for	Module availability	Applicability
elective	1^{st} or 3^{rd} semester	every winter semester	- B.Sc. IPSP - M.Sc. Meteorology
Workload	**Tutorial hours**	**Private study hours**	
240 h	90 h	150 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture "Experimental Physics 3 - Electromagnetic Waves and Foundations of Quantum Physics" (4 CHW / 60 h / 90 h)
- Exercise "Experimental Physics 3 - Electromagnetic Waves and Foundations of Quantum Physics" (2 CHW / 30 h / 60 h)

Participation requirements
None

Examinations (duration; weighting) and pre-examination requirements
Written exam (180 min; ×1)

Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.

Objectives

Students grasp the basic terms, phenomena and concepts of optics and quantum physics. After active participation in the module they are able to analyze and solve problems from these areas independently. They can apply the acquired knowledge to typical experiments and transfer it to new problems. They are able to describe and discuss problems and solutions of tasks in optics and quantum physics using appropriate scientific terms.

Content

Electromagnetic waves
- Electromagnetic waves: wave equation, electromagnetic spectrum, plane and spherical waves, energy transport and Poynting vector, polarization, reflection and transmission, Fresnel formulas, Hertzian dipole
- Wave optics: Huygen's principle, diffraction, interference, coherence, interferometer, single and double slit, diffraction grating

Geometrical optics:
- Reflection, refraction, mirrors, lenses, prisms, optical instruments, dispersion, imaging errors

Fundamentals of quantum physics:
- Particle properties of light: photoelectric effect, blackbody radiation, photon gas, Planck's law of radiation
- Structure of matter: Thomson's atomic model, Rutherford scattering, Rutherford's and Bohr's atomic models
- Matter waves: Heisenberg principle of uncertainty, wave function, probability interpretation
- Schrödinger equation, quantum states, potential well, harmonic oscillator, tunnel effect, correspondence principle

References

- M. Alonso / E. J. Finn: Physics, Addison-Wesley Longman
- D. Halliday / R. Resnick / J. Walker: Fundamentals of Physics, Wiley-VCH

Module title	Module number
Theoretical Physics 1 - Classical Mechanics 1	**12-PHY-BIPTP1**
Module title (German)	ECTS
Theoretische Physik 1 - Klassische Mechanik 1	**8 CP**

Responsibility

Director of the Institute for Theoretical Physics

Module type	Recommended for	Module availability	Applicability
elective	1^{st} or 3^{rd} semester	every winter semester	- B.Sc. IPSP - M.Sc. Meteorology
Workload	Tutorial hours	Private study hours	
240 h	90 h	150 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)

- Lecture “Theoretical Physics 1 - Classical Mechanics 1” (4 CHW / 60 h / 100 h)
- Exercise “Theoretical Physics 1 - Classical Mechanics 1” (2 CHW / 30 h / 50 h)

Participation requirements

Students, who have already completed the module "Mathematische Methoden - Methoden der klassischen Physik" (12-PHY-BMAME1) in the Bachelor's program cannot select this module

Examinations (duration; weighting) and pre-examination requirements

Written exam (180 min; ×1)

Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.

Objectives

The students
- learn basic principles of mechanics and can apply them to relevant problems;
- master basic calculation methods of classical mechanics;

Content

- Newton’s axioms, laws of conservation
- Differentiating and integrating functions of one variable, calculating with complex numbers, solving ordinary differential equations
- Non-inertial systems
- Calculating with matrices and determinants, coordinate systems and rotations
- Kepler problem, mechanics of mass points and rigid bodies, small oscillations
- linear systems of equations, eigenvalue problems

References

- D. Kleppner and R.J. Kolenkov, "An Introduction to Mechanics", Cambridge University Press 2010
- J. Hohnerkamp, H. Römer: "Theoretical Physics: A Classical Approach", Springer, 1993

Module title	Module number
Theoretical Physics 2 - Electrodynamics 1	**12-PHY-BIPTP2**
Module title (German) **Theoretische Physik 2 - Elektrodynamik 1**	ECTS **8 CP**

Responsibility
Director of the Institute for Theoretical Physics

Module type	Recommended for	Module availability	Applicability
elective	2nd semester	every summer semester	- B.Sc. IPSP - M.Sc. Meteorology
Workload 240 h	Tutorial hours 90 h	Private study hours 150 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Theoretical Physics 2 - Electrodynamics 1” (4 CHW / 60 h / 100 h) - Exercise “Theoretical Physics 2 - Electrodynamics 1” (2 CHW / 30 h / 50 h)
Participation requirements Students, who have already completed the module "Mathematische Methoden - Methoden der klassischen Physik" (12-PHY-BMAME1) in the Bachelor's program cannot select this module
Examinations (duration; weighting) and pre-examination requirements Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*

Objectives	The students - know basic concepts of classical electrodynamics and can apply them to relevant issues; - master basic calculation methods of classical electrodynamics;
Content	- Maxwell's equations, laws of conservation - Introduction into vector analysis in R^3: div, red, grad, area and volume integrals - Electrostatics and magnetostatics in vacuum and media, law of induction and quasi-stationary currents - Elementary solution methods for partial differential equations
References	- D.J. Griffiths "Introduction to Electrodynamics" Pearson Education 2008 - D. Jackson "Classical Electroynamics" John Wiley & Sons 1998

Module title **Theoretical Physics 4 - Quantum Mechanics**			Module number **12-PHY-BIPTP4**
Module title (German) **Theoretische Physik 4 - Quantenmechanik**			ECTS **8 CP**
Responsibility Director of the Institute for Theoretical Physics			
Module type elective	Recommended for 2nd semester	Module availability every summer semester	Applicability - B.Sc. IPSP - M.Sc. Meteorology
Workload 240 h	Tutorial hours 90 h	Private study hours 150 h	
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “ Theoretical Physics 4 - Quantum Mechanics” (4 CHW / 60 h / 100 h) - Exercise “ Theoretical Physics 4 - Quantum Mechanics” (2 CHW / 30 h / 50 h)			
Participation requirements None			
Examinations (duration; weighting) and pre-examination requirements Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*			

Objectives	The students - cover the basic concepts for the description of physical systems in quantum mechanics; - know the concept and the formal apparatus of quantum mechanics as well as typical fields of application; - can use it to address simple problems;
Content	- Elementary phenomena, Schrödinger’s equation, superposition principle, states in Hilbert space - Observables, operators in Hilbert space, eigenvalue, spectrum, scattering, time evolution, uncertainty relation - One-dimensional problems - Theory of angular momentum, spin - Central potentials, introduction into scattering theory and perturbation theory
References	- D.J. Griffiths "Introduction to Quantum Mechanics", Pearson Education 2005 - F. Schwabl "Quantum mechanics" Springer 2008

Module title **Theoretical Physics 5 - Statistical Physics**			Module number **12-PHY-BIPTP5**
Module title (German) **Theoretische Physik 5 - Statistische Physik**			ECTS **8 CP**
Responsibility Director of the Institute for Theoretical Physics			
Module type elective	Recommended for 1st or 3rd semester	Module availability every winter semester	Applicability - B.Sc. IPSP - M.Sc. Meteorology
Workload 240 h	Tutorial hours 90 h	Private study hours 150 h	
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Theoretical Physics 5 - Statistical Physics” (4 CHW / 60 h / 100 h) - Exercise “Theoretical Physics 5 - Statistical Physics” (2 CHW / 30 h / 50 h)			
Participation requirements None			
Examinations (duration; weighting) and pre-examination requirements Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*			

Objectives	The students - can illustrate and explain the basic concepts of thermodynamics and statistical physics of equilibrium orally and written form; - can use them to investigate and predict the behaviour of simple classical and quantum mechanical many-body systems in thermodynamic equilibrium; - can examine and solve simple model problems independently and discuss their approach;
Content	- Terms and principles of thermodynamics, thermodynamic potentials, equilibrium conditions, ideal and real gases, phase transitions - Basic concepts of kinetic gas theory, statistical mechanics of equilibrium, classical and quantum systems, approximation methods - Introduction into quantum statistics
References	- C. Kittel and H. Kroemer, "Thermal Physics", 2nd ed., Freeman - M. Kardar, "Statistical Mechanics of Particles", Cambridge University Press, 2007

Modules from the German Bachelor program "B.Sc. Physik"

Attention: Lectures and examinations in modules of the German Bachelor program "B.Sc. Physik" will be held in German language!

Module title			Module number
Experimentalphysik 3 - Optik und Quantenphysik			**12-PHY-BPEP3**
Module title (English) **Experimental Physics 3 - Optics and Quantum Physics**			ECTS **8 CP**
Responsibility Director of the Peter Debye Institute for Soft Matter Physics / Director of the Felix Bloch Institute for Solid State Physics			
Module type elective	Recommended for 1st or 3rd semester	Module availability every winter semester	Applicability - B.Sc. Physik - M.Sc. Meteorology
Workload 240 h	Tutorial hours 90 h	Private study hours 150 h	
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture "Experimentalphysik 3 - Optik und Quantenphysik" (4 CHW / 60 h / 100 h) - Exercise "Experimentalphysik 3 - Optik und Quantenphysik" (2 CHW / 30 h / 50 h)			
Participation requirements None			
Examinations (duration; weighting) and pre-examination requirements Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*			

Objectives	Students grasp the basic terms, phenomena and concepts of optics and quantum physics. After active participation in the module, they are able to analyse and to solve independently problems in optics and quantum physics. They can apply the acquired knowledge on typical experiments and transfer it to new problems. They are able to use terms from optics and quantum physics in a scientific way and to present and discuss their solutions of problems in optics and quantum physics.
Content	Optics: - Electromagnetic waves: wave equation, electromagnetic spectrum, plane and spherical waves, energy transport and Poynting vector, polarization, reflection and transmission, Fresnel's formulas, Hertzian dipole - Special Theory of Relativity - Geometric optics: reflection, refraction, mirrors, lenses, prisms, optical Instruments, dispersion, imaging errors - Wave optics: Huygens principle, diffraction, interference, coherence, interferometer, single and double slit, diffraction grating Fundamentals of quantum physics: - Photoelectric effect, blackbody radiation, photon gas, Planck's radiation law, Rutherford scattering, Bohr's atomic model, wave-particle dualism - wave function, Schrödinger equation, quantum states, potential well, tunnel effect, correspondence principle, uncertainty relation
References	- Demtröder "Elektrizität und Optik" Springer-Verlag 2009 - A. P. French "Special Relativity", The M.I.T. Introductory Physics Series - Haken, Wolf "Atom- und Quantenphysik: Einführung in die experimentellen und theoretischen Grundlagen" Springer 2004 - Alonso, Finn "Physik" Oldenbourg 2000

<table>
<tr><td colspan="3">Module title
Experimentalphysik 4 - Struktur der Materie</td><td>Module number
12-PHY-BPEP4</td></tr>
<tr><td colspan="3">Module title (English)
Experimental Physics 4 - Structure of Matter</td><td>ECTS
8 CP</td></tr>
<tr><td colspan="4">Responsibility
Director of the Peter Debye Institute for Soft Matter Physics / Director of the Felix Bloch Institute for Solid State Physics</td></tr>
<tr><td>Module type
elective</td><td>Recommended for
2nd semester</td><td>Module availability
every summer semester</td><td rowspan="2">Applicability
- B.Sc. Physik
- M.Sc. Meteorology</td></tr>
<tr><td>Workload
240 h</td><td>Tutorial hours
90 h</td><td>Private study hours
150 h</td></tr>
<tr><td colspan="4">Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Experimentalphysik 4 - Struktur der Materie” (4 CHW / 60 h / 100 h)
- Exercise “Experimentalphysik 4 - Struktur der Materie“ (2 CHW / 30 h / 50 h)</td></tr>
<tr><td colspan="4">Participation requirements
None</td></tr>
<tr><td colspan="4">Examinations (duration; weighting) and pre-examination requirements
Written exam (180 min; ×1)
Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.</td></tr>
<tr><td>**Objectives**</td><td colspan="3">Students grasp the basic terms, phenomena and concepts of atomic, molecular, nuclear and elementary particle physics. After active participation in the module they are able to analyze and solve tasks from atomic, molecular, nuclear and elementary particle physics. They can apply the acquired knowledge to typical experiments and transfer it to new problems. They are able to discuss problems and solutions of tasks in atomic, molecular amd nuclear and elementary particle physics using appropriate terms of these fields.</td></tr>
<tr><td>**Content**</td><td colspan="3">Nuclear physics:
- Hydrogen atom: spectral lines, Schrödinger equation, orbitals, energy and quantization of angular momentum
- Multi-electron atoms: spin and Stern-Gerlach experiment, Pauli principle, Hund's rules, systematics of atomic structure, periodic table, atoms in external fields, Zeeman effect, Paschen-Back effect, Stark effect, optical transitions, selection rules
Fundamentals of quantum statistics:
- Boltzmann, Fermi-Dirac, Bose-Einstein statistics, Bose-Einstein condensation, Superfluidity, ultracold quantum gases
Molecular physics:
- Chemical bonding, adiabatic approximation, molecular orbitals (LCAO), rotational and vibrational spectroscopy (Raman, Brillouin), Franck-Condon principle
Nuclear physics:
- Nuclear properties, nuclear forces and nuclear structure models. Nuclear reactions and -decays
Elementary particle physics:
- Elementary particles, processes, symmetries, accelerators and detection methods
- strong, electromagnetic, weak interaction</td></tr>
<tr><td>**References**</td><td colspan="3">- Demtröder "Atome, Moleküle, Festkörper" Springer-Verlag Berlin Heidelberg 2009
- Haken, Wolf "Moleküle und Quantenchemie" Springer Berlin Heidelberg 2006
- Haken, Wolf "Molecular Physics and Elements of Quantum Chemistry" Springer 2010
- Haken, Wolf "Atom- und Quantenphysik" Springer Berlin Heidelberg 2004</td></tr>
</table>

Module title **Experimentalphysik 5 - Festkörperphysik**			Module number **12-PHY-BEP5**
Module title (English) **Experimental Physics 5 - Solid State Physics**			ECTS **8 CP**
Responsibility Director of the Peter Debye Institute for Soft Matter Physics / Director of the Felix Bloch Institute for Solid State Physics			
Module type elective	Recommended for 1^{st} or 3^{rd} semester	Module availability every winter semester	Applicability - B.Sc. Physik - M.Sc. Meteorology
Workload 240 h	Tutorial hours 90 h	Private study hours 150 h	
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture “Experimentalphysik 5 - Festkörperphysik” (4 CHW / 60 h / 100 h) - Exercise “Experimentalphysik 5 - Festkörperphysik” (2 CHW / 30 h / 50 h)			
Participation requirements None			
Examinations (duration; weighting) and pre-examination requirements Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*			

Objectives	Students grasp the basic terms, phenomena and concepts of solid state physics. After active participation in the module they are able to to analyse tasks from solid state physics and to solve them independently You are able to apply the acquired knowledge to typical experiments and to new problems are transferred. They are able to communicate with terms of to discuss solid state physics scientifically and their solutions to tasks of solid-state physics to be presented and justified.
Content	- Drude model: free electron gas, Hall effect, frequency dependent conductivity, optical properties - Crystals:chemical bonds in solids, crystal structures, Bravais lattice and reciprocal lattice, diffraction methods - Lattice vibrations: Classical and quantum theory of the harmonic lattice, phonons, state density, thermal properties, elastic constants, spectroscopic methods - Conduction electrons in solids: Bloch's theorem, quasi-free electron model, band model, tight-binding model, electrical and thermal properties, magnetotransport phenomena, fundamentals of semiconductor physics and superconductivity
References	- C. Kittel: Introduction to Solid State Physics (Wiley) - J. Sólyom: Fundamentals of the Physics of Solids (Vol. 1 and 2) (Springer) - S. Hunklinger: Festkörperphysik (Springer) - G. Grosso and G. P. Parravicini: Solid State Physics (Academic Press) - Ashcroft and Mermin: Solid State Physics (Holt-Saunders Int. Ed.) - Ibach and Lüth: Solid-State Physics (Springer) - Duan and Guojun, Introduction to Condensed Matter Physics Vol. 1 (World Scientific)

Module title			Module number
Theoretische Physik 1 - Theoretische Mechanik			**12-PHY-BTP1**
Module title (English) **Theoretical Physics 1 - Classical Mechanics**			ECTS **8 CP**
Responsibility Director of the Institute for Theoretical Physics			
Module type elective	Recommended for 1st or 3rd semester	Module availability every winter semester	Applicability - B.Sc. Physik - M.Sc. Meteorology
Workload 240 h	Tutorial hours 90 h	Private study hours 150 h	
Teaching units (CHW - contact hours per week / tutorial hours / private study hours) - Lecture "Theoretische Physik 1 - Theoretische Mechanik" (4 CHW / 60 h / 100 h) - Exercise "Theoretische Physik 1 - Theoretische Mechanik" (2 CHW / 30 h / 50 h)			
Participation requirements None			
Examinations (duration; weighting) and pre-examination requirements Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*			

Objectives	Students know basic principles and formalisms of Theoretical Mechanics, gain a first insight into systematized thinking and formal description of physical problems and grasp this approach as essential for the construction of physical theories. After active participation in the module, they are able to analyze and to solve problems from Theoretical Mechanics independently. They are able to transfer the acquired knowledge to new problems. They are able to discuss scientifically using terms from Theoretical Mechanics and to present and discuss their solutions to problems from Theoretical Mechanics. The students will be prepared for quantum mechanics and statistical physics.
Content	Newtonian mechanics: - Newtonian Axioms, non-inertial systems, laws of conservation, Kepler problem, mechanics of mass points and rigid bodies, small oscillations Lagrange methods: - Constraints, Lagrange equations of 1st and 2nd order, Noether Theorem, Hamilton's principle Hamiltonian mechanics: - Hamiltonian equations, canonical transformations, Hamilton-Jacobi equation, integrable systems
References	- J. Hohnerkamp, H. Römer: "Theoretical Physics: A Classical Approach", Springer, 1993 - H. Goldstein, C.P. Poole, J. Safko: "Classical Mechanics", Wiley, 2006

Module title	Module number
Theoretische Physik 2 - Quantenmechanik	**12-PHY-BTP2**
Module title (English) **Theoretical Physics 2 - Quantum Mechanics**	ECTS **8 CP**

Responsibility: Director of the Institute for Theoretical Physics			
Module type: elective	Recommended for: 2^{nd} semester	Module availability: every summer semester	Applicability: - B.Sc. Physik - M.Sc. Meteorology
Workload: 240 h	Tutorial hours: 90 h	Private study hours: 150 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)

- Lecture “Theoretische Physik 2 - Quantenmechanik” (4 CHW / 60 h / 100 h)
- Exercise “Theoretische Physik 2 - Quantenmechanik” (2 CHW / 30 h / 50 h)

Participation requirements

None

Examinations (duration; weighting) and pre-examination requirements

Written exam (180 min; ×1)

Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.

Objectives	The students - grasp basic concepts for the description of physical systems in quantum mechanics; - know the concept and the formal apparatus of quantum mechanics as well as typical examples of their application; - can use it to process simple problems;
Content	- Elementary phenomena, Schrödinger equation, superposition principle, states in Hilbert space - Observables, operators in Hilbert space, eigenvalue, spectrum, scattering, time evolution, uncertainty relation - One-dimensional problems - Theory of angular momentum, spin - Central potentials, introduction into scattering theory and perturbation theory
References	- A. Messiah: "Quantum Mechanics", Dover, 1999 - F. Schwabl: "Quantenmechanik", Springer, 2008

Module title	Module number
Theoretische Physik 3 - Statistische Physik	**12-PHY-BTP3**
Module title (English) **Theoretical Physics 3 - Statistical Physics**	ECTS **8 CP**

Responsibility
Director of the Institute for Theoretical Physics

Module type	Recommended for	Module availability	Applicability
elective	1st or 3rd semester	every winter semester	- B.Sc. Physik - M.Sc. Meteorology
Workload	**Tutorial hours**	**Private study hours**	
240 h	90 h	150 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)

- Lecture “Theoretische Physik 3 - Statistische Physik” (4 CHW / 60 h / 100 h)
- Exercise “Theoretische Physik 3 - Statistische Physik” (2 CHW / 30 h / 50 h)

Participation requirements

None

Examinations (duration; weighting) and pre-examination requirements

Written exam (180 min; ×1)

Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.

Objectives	The students - know the basic concepts of statistical physics of classical and quantum systems in thermodynamic equilibrium; - can use it to handle simple relevant issues;
Content	- Terms and principles of thermodynamics, thermodynamic potentials, equilibrium conditions, ideal and real gases, phase transitions - Basic ideas of kinetic gas theory, statistical mechanics of equilibrium, classical and quantum systems, approximation methods - Introduction into quantum statistics
References	- F. Schwabl, "Statistische Mechanik", Springer, 2006 - M. Kardar, "Statistical Mechanics of Particles", Cambridge University Press, 2007

Module title	Module number
Theoretische Physik 4 - Elektrodynamik & klassische Feldtheorie	**12-PHY-BTP4**
Module title (English) **Theoretical Physics 4 - Electrodynamics and Classical Field Theory**	ECTS **8 CP**

Responsibility
Director of the Institute for Theoretical Physics

Module type	Recommended for	Module availability	Applicability
elective	2nd semester	every summer semester	- B.Sc. Physik - M.Sc. Meteorology
Workload	**Tutorial hours**	**Private study hours**	
240 h	90 h	150 h	

Teaching units (CHW - contact hours per week / tutorial hours / private study hours)
- Lecture “Theoretische Physik 4 - Elektrodynamik & klassische Feldtheorie” (4 CHW / 60 h / 100 h) - Exercise “Theoretische Physik 4 - Elektrodynamik & klassische Feldtheorie” (2 CHW / 30 h / 50 h)
Participation requirements
None
Examinations (duration; weighting) and pre-examination requirements
Written exam (180 min; ×1) *Pre-examination requirements: Weekly exercises with tasks related to the module content. Points are awarded for solutions. 50% of the total points for the entire semester have to be achieved as prerequisite for admission to the exam.*

Objectives	The students - know the concepts of classical electrodynamics and can apply them to relevant problems; - recognize the place of electrodynamics in the overall conceptual building of physics; - know concepts of field theory and methods of other fields of physics;
Content	- Special theory of relativity, Maxwell's equations, laws of conservation - Electrostatics and magnetostatics in vacuum and media, law of induction and quasi-stationary currents - Electromagnetic waves in vacuum and media, field of moving charges, radiation - Fundamentals of classical field theories (also from other areas of physics)
References	- J.D. Jackson "Classical Electrodynamics", Wiley

2.6 Free Elective Area

Any module(s) offered in other study programs can be chosen according to valid cooperation agreements. Further modules can be approved by the examination board upon request.

Cooperation agreements exist with the Institute for Geography. Please check section 1.1.2 for a list of the corresponding modules. Course language is German. Please check the Official Bulletins of Leipzig University for the module descriptions:
https://amb.uni-leipzig.de/?kat_id=270 and https://amb.uni-leipzig.de/?kat_id=794