Modules and Courses

Master of Science in Physics

23. Oktober 2025

Table of contents

1 List of Modules and Courses

1.1 Overview of the Modules

Module	**SWS**	**CP**
required modules		
Experimental Physics	3 V + 1 Ü	6
Theoretical Physics	4 V + 2 Ü	9
Seminars	4 S	8
Advanced laboratory course	8 P	10
sum		**33**
Research Phase		
Specialization	F	15
Methodological Knowledge	F	15
Master thesis	F	30
sum		**60**
Compulsory Elective Modules		
Topical Courses	3 V + 1 Ü	6
Advanced Theoretical Physics	4 V + 2 Ü	9
to choose		**12-27**
Elective Modules		
Focus Courses	2	3
Research Module	4 V	6
Subsidiary Subject (cf. chapter 1.3)		9-15
to choose		**0-15**
Total		**120**

1.2 List of Topical Courses

Here is a list of topical courses that are offered regularly. You will find the actual list for each semester in Jogustine.

- Condensed Matter Physics
  - Selected Topics in Condensed Matter Physics
  - Advanced Solid State Physics
  - Modern Experimental Methods in Condensed Matter Physics
  - Materials Science
  - Introduction to Advanced Materials - from soft matter to hard matter
  - Quantum Spintronics
  - Superconductivity
  - Nonequilibrium phenomena in quantum matter
  - Introduction to Condensed Matter Theory
  - Selected Chapters of Condensed Matter Theory
  - Theory of Soft Matter I
  - Modern Computational Techniques in Condensed/Soft Matter Physics
  - Computer Simulations in Statistical Physics
  - Soft Materials at Interfaces
  - Biophysics
  - Advanced theoretical solid state physics
  - Theory of Soft Matter II
- Quantum, Atomic and Neutron Physics
  - Quantum Optics (Q-Ex-1)
  - Photonics (Q-Ex-2)
  - Quantum Information (Q-Ex-3)
  - Precision Fundamental Physics (Q-Ex-4)
- Nuclear and Particle Physics
  - Statistics, Data Analysis and Simulation
  - Particle Detectors
  - Accelerator Physics
  - Particle Physics
  - Astroparticle Physics
  - Cosmology and General Relativity
  - Symmetries in Physics
  - Modern Methods in Theoretical High Energy, Particle and Nuclear Physics
  - Theoretical Particle Physics
  - Theoretical Nuclear Physics

- Introduction to Lattice Gauge Theory
- Introduction to String Theory
- Effective Field Theories
- Theoretical Astroparticle Physics
- Amplitudes and Precision Physics at the LHC
- Functional Methods and Exact Renormalization Group
- Advanced Particle Physics
- Advanced Chapters on Subatomic Physics
- Advanced Astroparticle- and Astrophysics
- Advanced Accelerator Physics

1.3 Subsidiary Subjects

Subsidiary Subject	SWS	CP
Chemistry		
Nuclear Chemistry	2 V + 1 Ü + 5 P	9
Nuclear Chemistry (with 1 additional advanced lecture)	4 V + 1 Ü + 5 P	12
Nuclear Chemistry (with 2 additional advanced lectures)	6 V + 1 Ü + 5 P	15
Introduction in Theoretical Chemistry	4 V + 1 Ü + 5 P	9
Theoretical Chemistry	4 V + 2 Ü + 10P	12
Computer Science		
Computer Science I	2 V + 2 Ü + 2 P	9
Computer Science II	4 V + 4 Ü	12
Computer Science III	4 V + 4 Ü + 2 P	15
Computer Science IV	4 V + 4 Ü + 2 S	16
Economics		
International Economics & Public Policy	6 V+Ü	12
Finance & Accounting	6 V+Ü	12
Marketing, Management & Operations	6 V+Ü	12
History of Natural Science		
History of Natural Science I	4 V + 4 S + 2 Ü	15
History of Natural Science II	2 HS + 2 S	9
Mathematics		
Functional Analysis	4 V + 2 Ü	9
Functional Analysis (with Functional Analysis II)	8 V + 2 Ü	15
Partial differential equations	4 V + 2 Ü	9
Partial differential equations (with partial differential equations II)	8 V + 2 Ü	15
Fundamentals in stochastics	4 V + 2 Ü	9
Fundamentals in stochastics (with stochastics I)	8 V + 2 Ü	15
Stochastics I	4 V + 2 Ü	9
Stochastics I (with stochastics II)	8 V + 2 Ü	15
Stochastics 2	8 V	15
Basic numerics	4 V + 2 Ü	9
Basic numerics (with numerical methods of ordinary differential equations)	8 V + 2 Ü	15
Numerics of differential equations	4 V + 2 Ü	9
Numerics of differential equations (with partial differential equations)	8 V + 2 Ü	15
Algebra	4 V + 2 Ü	9
Algebra (with “Fields, Rings, Modules”)	8 V + 2 Ü	15
Topology	4 V + 2 Ü	9
Topology (with “Algebraic curves and Riemannian surfaces”)	8 V + 2 Ü	15
Computer algebra	4 V + 2 Ü	9
Computer algebra (with Number Theory)	8 V + 2 Ü	15
Differential Geometry and Manifolds	4 V + 2 Ü	9
Function Theory	4 V + 2 Ü	9
Number Theory	4 V + 2 Ü	9
Functional Analysis	8 V + 2 Ü	15
Basics of Numerical Mathematics (with laboratory)	4 V + 2 Ü + 2 P	12

Subsidiary Subject	SWS	CP
Complex Differential Geometry	8 V + 2 Ü	15
Algebraic Geometry	8 V	15
In-depth module Analysis	8 V + 2 Ü	15
In-depth module Gauge Theory	8 V + 2 Ü	15
Meteorology		
Clouds and Aerosols		15
Dynamics of Weather and Climate		15
Modelling		14
Composition of the Atmosphere		13
Philosophy		
Modern Philosophy	6 S	15
Interdisciplinary Courses		
History of Natural Science I	3 V	3
History of Natural Science II	3 V	3

1.3.1 Further Subsidiary Subjects

Upon request additional subsidiary subjects can be added from other faculties of the university. Those need to be approved by the corresponding commitee („Fachausschusses für Studium und Lehre Physik“) and a dedicated contract has to be established with the faculty. The proposed subsidiary subject should be related to either natural sciences or mathematics. It is therefore advised to consult the head of the exams commitee before filing such a request.

2 Important Remarks

2.1 General Remarks

1. The language of all physics courses is English unless all participants are proficient in German and there is a consent to hold the course in German.

2. Within the Master of Science in Physics studies, a minimum of 120 credit points (CP) must be obtained. If the number of credit points is exceeded by more than 6 CP, the study advisor has to be contacted to discuss the situation.

3. Before completion of the master studies either

   a) all three experimental physics courses (Ex-5a, Ex-5b, Ex-5c, or Ex-A, Ex-B, Ex-C, respectively) and 5 main courses in theoretical physics

   b) or at least two of the three experimental physics courses and 6 main courses in theoretical physics

   have to be completed successfully. In case only one of the experimental physics courses was part of the bachelor studies a corresponding requirement will be issued at the time of admission to the master studies.

4. If you choose a subsidiary subject then you have to obtain at least 9 credit points in this subject. On request, subsidiary subjects not listed in this document may be chosen among courses given at the Johannes Gutenberg-Universität Mainz, the TU Darmstadt or the Goethe-Universität Frankfurt. Please consult the chair of the examination committee before submitting such a request. While many subsidiary subjects will only be given in German, it is worth asking the docent to provide the lectures in English if there is a need.

5. In case all three experimental physics lectures (Ex-5a, Ex-5b, Ex-5c, or Ex-A, Ex-B, Ex-C, respectively) were completed successfully before the start of the master studies, an additional topical course has to be taken.

6. Equivalent courses taken at other universities may be recognised with the credit points awarded for the corresponding course in Mainz. Moderate additional requirements may be imposed.

7. The interdisciplinary course (3 CP) is optional. In addition to the courses listed in this document, also courses from the “Studium Generale” and internships (“summer student programmes”) at large research laboratories may be accepted. Language courses outside of “Studium Generale” or internships in industry or research institutes can only be recognised after consulting the study advisor. The credit points are added to the points for the subsidiary subject and in total a maximum of 15 credit points can be obtained.

8. Additional main courses in theoretical physics can be chosen within the module Ädvanced Theoretical Physics". This module is optional.

9. In the case of outstanding performance (currently a final grade of 1.2 or or better and a grade of 1.0 for the Master’s thesis), the overall grade "passed with distinction"will be awarded, provided that the Master’s programme was concluded within 4 semesters (including the time required to complete the Master’s thesis and the final colloquium).

2.2 Rules and regulations

The academic rules and regulations of the MSc program in physics at the Johannes Gutenberg University Mainz are summarized in the so-called "Prüfungsordnung" – or in short – "PO" (see https://www.studium.fb08.uni-mainz.de/downloadcenter-physik/). As a legal document, it needs to be formulated in German. However, we are summarizing some important points (and pit-falls) below in English.

2.2.1 Introductory remarks

- If you have questions, you should first contact the student advisor ("Studienfachberater") or the manager of studies ("Studienmanager") via our contact form http://helpdesk.fb08.uni-mainz.de/?l=1 . The office of student affairs ("Studienbüro", Staudingerweg 7, room 05 430, 10-12 pm Mondays to Thursday) is responsible for transcripts and certification documents, maintains recognized achievements in Jogustine and accepts applications to the Examination Board.

- A module may comprise several courses, such as teaching classes, exercises and labs. In the MSc program, a module typically consists of lecture sessions and exercise classes.

- All modules in the MSc program are graded based either on written exams, oral exams, presentations, reports on projects, or laboratory work. The grade of Focus Courses do not enter the overall grade of the MSc.

- German grades are on a scale of 1.0 (best possible grade) to 4.0 (lowest passing grade). 5.0 is a failing grade. A popular formula to translate your grade into that of the German system is the so-called modified Bavarian formula

$$\frac{N_{max} - N}{N_{max} - N_{min}} \cdot 3 + 1.$$

  Where N_{max} is the highest possible grade in your home country's grading system, N_{min} is lowest possible passing grade in your home country's grading system and N the grade you want to convert.

2.2.2 How to register for a class and an exam?

At the JGU, we offer – with a few exceptions – a two-step registration process.

- At the end of the preceding term, in the week before the term starts and during the first week of lectures, students register their classes via Jogustine https://www.info.jogustine.uni-mainz.de/anmeldephasen/lehrveranstaltungsanmeldephasen/. You may drop out of a class without problems.

- Around mid-term, however, Jogustine will allow you for two weeks to register for the exam if you opt for this. The registration periods can be found here: https://www.info.jogustine.uni-mainz.de/anmeldephasen/pruefungsanmeldephasen/. Such a registration is binding! Note that our department allows you retract from your registration, as long as you do it 1 week (1pm) before the exam is scheduled.

- After expiry of the registration or de-registration deadlines, a withdrawal is only possible in justified individual cases. This applies, for example, if you have been sick and this fact is proven by a medical certificate.

2.2.3 What happens if you fail an exam and have to repeat?

- Failed *compulsory* and *elective* module examinations may be repeated at most twice. An oral supplementary examination may, however, be approved by the examination committee following a written application to the examination board. A grade of 4.0 will be given in case the supplementary exam has been passed.
- It is not allowed to repeat an exam that was passed before.
- Students who have not passed a compulsory elective module examination may switch to a different elective module after having failed one, twice or three times. For the new elective module, the student receives three more attempts to successfully complete the exam.
- The registration for the first repetition of a module examination or partial module examination should take place within six months after the failure and the second repetition of the exam should take place within twelve months of the failure of the first repetition; the registration.
- The registrations are performed automatically by the examination office, unless the exam has been passed in the mean-time.
- Only in justified cases, longer deadlines may be granted for the first and a second repetition. However, the time period may not exceed one year and nine months. If the deadlines to repeat the examinations have been missed, the exams are considered failed.
- If an examination can no longer be repeated, the Master's program is considered failed and the continuation of studies in the same master's program is no longer possible in a German University.

2.2.4 What happens if you fail to participate in an exam or withdraw from the exam?

- If the candidate does not appear to a duly established and notified appointment without good reasons or he or she steps back from the exam without valid reasons, the grade is rated as "not sufficient" (5,0).
- Exams are also considered failed if the candidate did not complete the exam or file a written report (e.g. the Master's thesis) within the prescribed time limits.
- If you disagree with the decision, the reasons for the failure or withdrawal need to be promptly notified in writing to the examination board and made credible. Should the Examining Board recognize the reasons, the exam will be re-scheduled.
- If the candidates fails to appear or withdraws from the exam because of illness, this must be proven by a medical certificate at the latest by the third day after the exam date.

2.3 Recognition of achievements

Achievements obtained in other study programs in Mainz or abroad can be recognized if there is no significant difference with respect to corresponding achievements within the MSc in physics in Mainz. Within the recognition achievements can be combined or split in order to match the formal criteria on e.g. needed credict points. Each case will be looked at individually and discussed with the applicant. The corresponding recognition form to be filled out can be found here:
http://www.studium.fb08.uni-mainz.de/downloadcenter-physik/

2.4 Remarks Concerning Research Phase

1. The research phase of the Master of Science in Physics programme consists of the three modules "Specialization" (3 months, seminar talk without grades, 15 CP), "Methodological Knowledge" (3 months, graded either through a seminar talk or a portfolio of documents representing the work, 15 CP) and "Master's Thesis" (6 months including a colloquium, 30 CP). These three modules are considered as one unit and have to be completed consecutively within one year.

2. Students are allowed to enrol into the research phase if at most one of the required courses to reach the 60 CP is missing (e.g. a Topical Course, a Focus Course or one of the two seminars). The start of the master thesis is 6 month after the start of the research phase. At this point in time, at least 60 of the required credit points (§6 subparagraph 2) have to be collected.

3. As the module "Specialization" is part of the preparation towards the master's thesis, it cannot be taken in parallel to the 6 months long Master's Thesis module.

4. A change of the master's thesis advisor can only happen once. This change has to be done before the start of the module "Methodological Knowledge".

5. The enrolment into the research phase is processed by the "Studienbüro Physik" with the help of this form[1]. The "Studienbüro" will then take care of the actual enrolment inside Jogustine.

6. A master's thesis outside the department of physics, mathematics and computer science (08) has to be requested (please submit an informal request at the Studienbüro). The primary evaluation of an external master's thesis has to be provided by a professor of the department 08.

7. The end date of the master's thesis may be extended by at most 4 weeks by the chair of the examination committee. For this to happen, the candidate has to submit a justified written request to the "Studienbüro" which has also to be signed by the corresponding thesis advisor.

8. The "Studienbüro" will enter the mark for the module "Methodological Knowledge" into the system at the end of the one-year research phase. The thesis advisors are requested to submit the mark of the module "Methodological Knowledge" when handing in the primary evaluation to the "Studienbüro".

9. In case the master's thesis is failed, the module can be repeated once. The new subject of the master thesis has to be sufficiently close to the subjects of the "Specialization" and "Methodological Knowledge" modules.

[1] https://www.blogs.uni-mainz.de/fb08-studium/files/2017/08/PHY_MSc_Anmeldeformular_2-seitig.pdf

2.5 Examples for Module Sequence

The following tables show examples for the module sequence for students starting in the winter or in the summer term:

Example of Module Sequence (Nuclear Chemistry as subsidiary subject)

Term						∑
4	**Master Thesis** Thesis 29 LP Coloquium 1 LP					30 LP
3	**Specialization** 15 LP			**Methodological Knowledge** 15 LP		30 LP
2	**Topical Course** 3V + 1Ü 6 LP	**Advanced Laboratory** Part 2 (4P) 5 LP Part 1 (4P) 5 LP	**Topical Course** 3V + 1Ü 6 LP	**Seminars** Seminar 2 4 LP (2S)	**Subsidiary Subject** e.g. Chemistry Laboratory 5 LP (5P)	31 LP 23 SWS
1	**Experimental Physics** 3V + 1Ü 6 LP	**Theoretical Physics** 4V + 2Ü 9 LP	**Topical Course** 3V + 1Ü 6 LP	Seminar 1 4 LP (2S)	Nuclear Chemistry (2V+1Ü) 4 LP	29 LP 19 SWS
						120 LP

Example of Module Sequence (no subsidiary subject)

Term						∑
4	**Master Thesis** Thesis 29 LP Coloquium 1 LP					30 LP
3	**Specialization** 15 LP			**Methodological Knowledge** 15 LP		30 LP
2	**Focus Course** 1.5V + 0.5Ü 3 LP	**Advanced Laboratory** Part 2 (4P) 5 LP Part 1 (4P) 5 LP	**Topical Course** 3V + 1Ü 6 LP	**Seminars** Seminar 2 4 LP (2S)	**Advanced Theoretical Physics** 4V + 2Ü 9 LP	32 LP 22 SWS
1	**Experimental Physics** 3V + 1Ü 6 LP	**Theoretical Physics** 4V + 2Ü 9 LP	**Topical Course** 3V + 1Ü 6 LP	Seminar 1 4 LP (2S)	**Focus Course** 1.5V + 0.5Ü 3 LP	28 LP 18 SWS
						120 LP

Example of Module Sequence (more topical courses)

Term						∑
4	**Master Thesis** Thesis 29 LP Coloquium 1 LP					30 LP
3	**Specialization** 15 LP			**Methodological Knowledge** 15 LP		30 LP
2	**Focus Course** 1.5V + 0.5Ü 3 LP	**Advanced Laboratory** Part 2 (4P) 5 LP Part 1 (4P) 5 LP	**Topical Course** 3V + 1Ü 6 LP	**Seminars** Seminar 2 4 LP (2S) - - - - - - - - - - - - - - - Seminar 1 4 LP (2S)	**Topical Course** 3V + 1Ü 6 LP	29 LP 20 SWS
1	**Experimental Physics** 3V + 1Ü 6 LP	**Theoretical Physics** 4V + 2Ü 9 LP	**Topical Course** 3V + 1Ü 6 LP		**Topical Course** 3V + 1Ü 6 LP	31 LP 20 SWS
						120 LP

Example of Module Sequence (one Focus Course during research phase)

Term						∑
4	**Master Thesis** Thesis 29 LP Coloquium 1 LP					30 LP
3	**Specialization** 15 LP	**Focus Course** 1.5V + 0.5Ü 3 LP		**Methodological Knowledge** 15 LP		33 LP 2 SWS
2	**Focus Course** 1.5V + 0.5Ü 3 LP	**Advanced Laboratory** Part 2 (4P) 5 LP Part 1 (4P) 5 LP		**Seminars** Seminar 2 4 LP (2S) - - - - - - - - - - - - - - - Seminar 1 4 LP (2S)	**Advanced Theoretical Physics** 4V + 2Ü 9 LP	26 LP 18 SWS
1	**Experimental Physics** 3V + 1Ü 6 LP	**Theoretical Physics** 4V + 2Ü 9 LP	**Topical Course** 3V + 1Ü 6 LP		**Topical Course** 3V + 1Ü 6 LP	31 LP 20 SWS
						120 LP

3 Detailed description of the Modules and Courses

3.1 Experimental Physics

Modul Ex-A	**Atom- und Quantenphysik** *Atomic and Quantum Physics*					**08.128.22071**
Compulsory or elective module	**P**					
Credit points and workload	**7 LP = 210 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Vorlesung mit Übung „Atom- und Quantenphysik“		4-6	P		147 h	7 LP
Vorlesung	V			4 SWS		
Übung	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	gemäß §5 Abs. 3					
Course achievements	Erfolgreiche Bearbeitung von Übungsaufgaben und/oder Projekten					
Module examination	Klausur (Umfang 120 Min., Bearbeitungszeit maximal 180 Min.) oder mündliche Prüfung (30 Min.)					

Qualification and program goals / Competences

Die Studierenden sollen

- grundlegende Kenntnisse der Physik der Atome, Moleküle und Quanten erlangen,
- Aufbau von Atomen und einfachen Molekülen sowie deren Wechselwirkung mit elektromagentischen Feldern,
- quantenmechanisches Wissen an praktischen Beispielen einsetzen und vertiefen sowie
- Einblick erhalten in moderne Verfahren der Atomphysik, Spektroskopie und Manipulation von Quantensystemen

Course content

Tiefgehende Einführung in die experimentelle Quantenphysik von Atomen und Molekülen und deren Wechselwirkung mit Licht, sowie deren praktische Anwendung. Die Veranstaltung umfasst die folgenden Themen:

- Relativistische Effekte und Dirac Gleichung beim Wasserstoffatom, Einflüsse des Kerns, Atome in äußeren Feldern
- Atome in elektromagnetischen Feldern – Licht-Materie-Wechselwirkung, kohärente und spontane Emissionsprozesse
- Mehrelektronensysteme, Grundlagen der Laserspektroskopie
- Ausgewählte Anwendungen: z.B. Manipulation und Fallen für neutrale Atome, Moleküle und Ionen, Ramsey-Methode, Atomuhr, Laser
- Grundlagen der Molekülphysik

Literature

- Physics of Atoms and Molecules, B.H. Bransden & C.J. Joachain
- Atom- und Quantenphysik, H. Haken & H.C. Wolf
- Experimentalphysik 3: Atome, Moleküle und Festkörper, Demtröder
- speziellere Fachliteratur

Entry requirements	

Modul Ex-A	**Atom- und Quantenphysik** ***Atomic and Quantum Physics***	**08.128.22071**
Recommended prerequisites		
Language	Unterrichtssprache Englisch Prüfungssprache Deutsch oder Englisch	
Weighting of the achievement in the overall grade	7/180	
Module frequency	Jedes Semester	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. P. Windpassinger	
Applicable to the following programs	B.Sc. Physik, B.Sc. Angewandte Physik m.S.I., M.Sc. Physik, M.Sc. Mathematik	
Miscellaneous	Sprache: Deutsch oder – auf Wunsch – Englisch Wird die Vorlesung in englischer Sprache gehalten, so muss für B.Sc. Studierence die Möglichkeit bestehen, die Prüfungsleistungen in deutscher Sprache durchzuführen. Konkret müssen Klausuren auch in deutscher Sprache zur Verfügung gestellt werden und Übungsaufgaben können auch in deutscher Sprache eingereicht werden.	

Modul Ex-B	**Kern- Teilchen- und Astrophysik** *Nuclear, Particle and Astrophysics*					**08.128.22072**
Compulsory or elective module	**P**					
Credit points and workload	**7 LP = 210 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Vorlesung mit Übung „Kern-, Teilchen- und Astrophysik“		4-6	P		147 h	7 LP
Vorlesung	V			4 SWS		
Übung	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	gemäß §5 Abs. 3					
Course achievements	Erfolgreiche Bearbeitung von Übungsaufgaben und/oder Projekten					
Module examination	Klausur (Umfang 120 Min., Bearbeitungszeit maximal 180 Min.) oder mündliche Prüfung (30 Min.)					

Qualification and program goals / Competences

Die Studierenden erhalten einen Überblick über das gesamte Gebiet der Kern- und Teilchenphysik und eine Einführung in den Gebiete der Astrophysik und Kosmologie. Nach erfolgreicher Teilnahme an diesem Modul sind die Studierenden in die Lage:

- die Funktionsweise der in Experimenten eingesetzten Beschleuniger und Detektorsysteme zu verstehen;
- mit theoretischen Konzepten umzugehen, die in der Kern- und Teilchenphysik wichtig sind
- die drei fundamentalen Wechselwirkungen der Teilchenphysik und ihre phänomenologischen Konsequenzen zu kennen und die entsprechenden Standardexperimente und theoretischen Modelle wiedergeben zu können
- kennen die wichtigsten Phänomene und Anwendungen der Kernphysik und können die Ideen der Kernphysik wiedergeben zu können
- die Bedeutung der Kern- und Teilchenphysik für die Astrophysik und Kosmologie nachvollziehen zu können

Nach erfolgreichem Abschluss dieses Moduls sind die Studierenden in der Lage, an weiterführenden und spezialisierenden Modulen in diesem Bereich teilzunehmen.

Course content

Die Veranstaltung umfasst die folgenden Themen:

- *Einführung:* Natürliche Einheiten, Symmetrien und Erhaltungssätze, relativistische Kinematik, Teilchenbeschleuniger und Teilchendetektoren.
- *Theoretische Konzepte:* Symmetrien, Streuung und Wirkungsquerschnitte, Klein-Gordon- und Dirac-Gleichung, Feynman-Diagramme.
- *Kernphysik:* Kernmassen und -radien, Formfaktoren, einfache Kernmodelle, Schalenmodell, α-, β- und γ-Zerfall, Kernfusion in Sternen, technische Anwendungen
- *Teilchenphysik:* gebundene Zustände (Quarkonia, Mesonen, Baryonen), inelastische und tiefinelastische Streureaktionen, Partonenmodell, Quark-Modell
- *Fundamentale Wechselwirkungen:* starke WW, e^+e^- Reaktionen, schwache WW und elektroschwache Vereinheitlichung, Paritätsverletzung, CP-Verletzung, W- und Z-Bosonen, CKM-Mischung, Higgs-Mechanismus, das Standardmodell der Teilchenphysik; Neutrino Oszillationen.
- *Einführung in die Kosmologie:* Frühes Universum, Friedmann Gleichungen, Kosmologische Beobachtungen, Dunkle Materie

Modul Ex-B	**Kern- Teilchen- und Astrophysik** ***Nuclear, Particle and Astrophysics***	**08.128.22072**

Literature

- Demtröder, Experimentalphysik 4, Springer Verlag
- Povh, Rith, Scholz "Teilchen und Kerne“ , Springer Verlag
- D. H. Perkins, Introduction to High Energy Physics, Cambridge UP
- D. Griffiths, Introduction to Elementary Particles, Wiley-VCH
- A. Liddle An introduction to modern cosmology", Wiley-VCH
- Diverse andere Lehrbücher zur Kern- und Teilchenphysik

Entry requirements	
Recommended prerequisites	
Language	Unterrichtssprache Englisch Prüfungssprache Deutsch oder Englisch
Weighting of the achievement in the overall grade	7/150
Module frequency	Jedes Semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. S. Tapprogge, Prof. Dr. M. Ostrick
Applicable to the following programs	B.Sc. Physik, B.Sc. Angewandte Physik m.S.I., M.Sc. Physik, M.Sc. Mathematik
Miscellaneous	Sprache: Deutsch oder – auf Wunsch – Englisch Wird die Vorlesung in englischer Sprache gehalten, so muss für B.Sc. Studierence die Möglichkeit bestehen, die Prüfungsleistungen in deutscher Sprache durchzuführen. Konkret müssen Klausuren auch in deutscher Sprache zur Verfügung gestellt werden und Übungsaufgaben können auch in deutscher Sprache eingereicht werden.

Modul Ex-C	**Physik kondensierter Materie** *Condensed Matter Physics*					**08.128.22073**
Compulsory or elective module	**P**					
Credit points and workload	**7 LP = 210 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Vorlesung mit Übung „Physik kondensierter Materie“		4-6	P		147 h	7 LP
Vorlesung	V			4 SWS		
Übung	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	gemäß §5 Abs. 3					
Course achievements	Erfolgreiche Bearbeitung von Übungsaufgaben und/oder Projekten					
Module examination	Klausur (Umfang 120 Min., Bearbeitungszeit maximal 180 Min.) oder mündliche Prüfung (30 Min.)					

Qualification and program goals / Competences

Nach Abschluss des Moduls „Physik der kondensierten Materie“ sollen die Studierenden erwerben:

- Kenntnisse über Grundlagen und Phänomene der Festkörperphysik und ausgewählter Spezialgebiete (Halbleiterphysik, Tieftemperaturphysik, Magnetismus,..),
- Kenntnisse über die elementaren Anregungen, bis hin zur Funktion in komplexen Zusammenhängen,
- Fertigkeiten zur Anwendung grundlegender Methoden und Prinzipien der Beschreibung von Festkörperphänomenen (Wechselwirkungen, Symmetrien, reziproker Raum, Modenspektren, Beschreibung der Störung der periodischen Gitterstruktur, makroskopische Quantenphänomene),
- wesentliche Elemente und Konzepte der Quantenmechanik, und Statistische Mechanik, um die Vielkörpernatur der Erscheinungen zu beschreiben.

Die Vorlesung legt die Grundlagen zu einem umfassenden Verständnis materialwissenschaftlicher Fragen und zur Erklärung der Effekte, auf denen zahllose technische Anwendungen der modernen Physik kondensierter Materie beruhen.

Course content

- Inter-Atomare Wechselwirkungen, Phasenverhalten
- Elektronen im Festkörper: Ein-Elektronen-Modelle, freies Elektronengas, Bändermodell, Metalle, Halbleiter, thermische Eigenschaften
- Gitterschwingungen, Anharmonische Effekte, Wärmeleitung
- Korrelierte Elektronensysteme: Magnetismus, Supraleitung, Topologische Systeme
- Anwendungen: Spektroskopie, Nichtgleichgewicht Phänomene, Spinphysik, Polymerphysik
- Einleitung in die Physik weicher Materie mit Grundlagen der Kontinuumsmechanik

Literature

- C. Kittel: Einführung in die Festkörperphysik
- H. Ibach, H. Lüth: Festkörperphysik
- N. W. Ashcroft, N. D. Mermin: Festkörperphysik
- R. Gross, A. Marx: Festkörperphysik

Entry requirements	
Recommended prerequisites	
Language	Unterrichtssprache Englisch Prüfungssprache Deutsch oder Englisch
Weighting of the achievement in the overall grade	7/180
Module frequency	Jedes Semester
Reasons for compulsory attendance	

Modul Ex-C	**Physik kondensierter Materie** ***Condensed Matter Physics***	**08.128.22073**
Persons responsible for this module	Prof. Dr. J. Demsar	
Applicable to the following programs	B.Sc. Physik, B.Sc. Angewandte Physik m.S.I., M.Sc. Physik, B.Sc. Angewandte Physik, M.Sc. Mathematik	
Miscellaneous	Sprache: Deutsch oder – auf Wunsch – Englisch. Wird die Vorlesung in englischer Sprache gehalten, so muss für B.Sc. Studierence die Möglichkeit bestehen, die Prüfungsleistungen in deutscher Sprache durchzuführen. Konkret müssen Klausuren auch in deutscher Sprache zur Verfügung gestellt werden und Übungsaufgaben können auch in deutscher Sprache eingereicht werden.	

3.2 Theoretical Physics

Modul Th5	**Advanced Quantum Mechanics**					**08.128.151**
Compulsory or elective module	**W**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced Quantum Mechanics"		1	P		207	9 LP
Lecture	V			4 SWS		
Excercises	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

The aim of this course is to get the students acquainted with advanced methods of quantum mechanics. In this context, basic concepts of classical and relativistic quantum field theory are discussed, thereby guiding students towards current research topics. During one third of the course, the lecturers will focus on selected topics of their choice.

Course content

- *Scattering theory (high priority optional topic):* Lippmann-Schwinger equation, optical theorem, Born approximation, scattering matrix, partial waves.
- *Many-particle systems:* Fock space and ladder operators for bosons and fermions, canonical formalism, canonic commutator relations, Hartree-Fock approximation
- *Interaction of non-relativstic matter with the radiation field (ideally, if time permits):* Emission and absorption of photons by atoms, scattering of photons by atoms.
- *Relativistic quantum field theory:* Klein-Gordon equation and Dirac equation, associated Lagrange densities. Ideally, if time permits: Interaction with the radiation field.
- *Additional in-depth topics* may vary according to the lecturer. Possible topics are:
  - Introduction to the path integral formalism.
  - Examples from many-particle physics, e.g., BCS theory of superconductivity.
  - Quantum optics.
  - Advanced group theory (Poincaré group, representation theory, Wigner theorem, central charges, symmetry breaking).
  - Weyl equation and Weyl spinors.
  - Relativistic treatment of the hydrogen atom.
  - Non-relativistic limit of the relativistic theory, Foldy-Wouthuysen transformation, relativistic corrections, origin of spin-orbit coupling.

Literature

Text books on theoretical physics, e.g., F. Schwabl, Quantenmechanik für Fortgeschrittene; W. Nolting, Theoretische Physik 7; J.J. Sakurai, Advanced Quantum Mechanics; J.D. Bjorken und S.D. Drell, Relativistische Quantenmechanik; S. Weinberg: Relativistische Quantenmechanik; M. Stone, The physics of quantum fields.

Entry requirements	
Recommended prerequisites	
Language	Course language English or German Examination language English or German
Weighting of the achievement in the overall grade	9/180 (BSc) or 9/120 (MSc)
Module frequency	Every semester

Modul Th5	**Advanced Quantum Mechanics**	**08.128.151**
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. S. Weinzierl	
Applicable to the following programs	B.Sc. Physik, M.Sc. Physik, B.Sc. Mathematik, M.Sc. Mathematik	
Miscellaneous	Course language: German or English on request	

Modul 165	**Relativistic Quantum Field Theory**					**08.128.165**
Compulsory or elective module	**WP**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Relativistic Quantum Field Theory" (WP)		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

Relativistic quantum field theory constitutes the foundation of the Standard Model of particle physics and is essential for an understanding of modern particle and hadron physics. This lecture is aimed at theoretical interested students who would like to make a start in the field of particle and hadron physics. The lecture provides the basic tools of relativistic quantum field theory. Subsequent specialized lectures may build on these basic tools.

Course content

Path integrals, Grassmann numbers, quantization of the Klein-Gordon field, Dirac, Maxwell and interacting fields, Wick's theorem, Feynman rules, cross sections, S-matrix, LSZ-reduction formula, basics and outlook of non-abelian gauge theories and spontaneous symmetry breaking.

Literature

Text books on theoretical physics, e.g.

- M.E. Peskin und D.V. Schroeder, An Introduction to Quantum Field Theory.
- M.D. Schwartz, Quantum Field Theory and the Standard Model

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	9/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. S. Weinzierl
Applicable to the following programs	M.Sc. Physics, M.Sc. Mathematics
Miscellaneous	Course language: English

Modul 170	**Advanced Statistical Physics**				**08.128.170**
Compulsory or elective module	**WP**				
Credit points and workload	**9 LP = 270 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced Statistical Physics" (WP)		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

Students will get to know advanced concepts and applications of statistical physics. They will learn central concepts on how to describe systems and materials whose behavior is dominated by large fluctuations, such as liquids in general, many plastics, most biomaterials, but also systems beyond the scope of natural sciences (e.g. in finance). The focus lies on general overarching principles, such as symmetries, cooperative processes and phase transitions, scales and scale free behavior, as well as coarse-graining. Specific examples will be selected based on the current research topics in Mainz and will to a large extent be related to soft matter.

Course content

- Basic concepts in a statistical description of complex systems at equilibrium and non-equilibrium, linear response and transport, stochastic processes, structure, correlations, and scattering;
- Modeling concepts, symmetries and conservation laws, coarse-graining concepts (reduction of degrees of freedom);
- Phase transitions, mean-field approaches, Landau theory, fluctuations and critical exponents, scale invariance and renormalization, and (possibly) basic concepts of statistical field theory;

Other topics are selected based on the preferences of the lecturers. Possibilities are: Non-equilibrium thermodynamics, stochastic thermodynamics, disordered systems and glasses, hydrodynamics at low Reynolds numbers, statistical physics of complex soft matter (e.g., polymers, self assembling systems, membranes, liquid crystals, colloidal systems, charged systems, entangled systems, biomolecules, biomaterials), as well as interdisciplinary applications of statistical physics, e.g., in finance.

Literature

- Chaikin/Lubensky: Principles of Condensed Matter Physics,
- Plischke/Bergersen: Equilibrium Statistical Physics.
- Landau-Lifshitz: Theoretical physics V und IX.
- Goldenfeld: Lectures on phase transitions and the renormalization group.
- Paul/Baschnagel: Stochastic processes. From physics to finance.
- Risken: The Fokker-Planck equation.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	9/120
Module frequency	At least once per year
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. F. Schmid

Modul 170	**Advanced Statistical Physics**	**08.128.170**
Applicable to the following programs	M.Sc. Physics, M.Sc. Mathematics	
Miscellaneous	Course language: English	

Modul 175	**Theoretical quantum optics and many body physics**				**08.128.175**
Compulsory or elective module	**WP**				
Credit points and workload	**9 LP = 270 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises „ Theoretical quantum optics and many body physics" (WP)		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

After this course, the students should amongst others:

- be able to apply advanced methods of Theoretical Quantum Physics,
- be familiar with the interpretation, examination and formulation of quantum field theories,
- have a deeper understanding of the most important phenomena and models of many-particle theory and theoretical quantum optics

This is to create a solid basis to deal with research-related topics in the field.

Course content

The course offers a profound theoretical introduction to the overlapping fields of theoretical many particle physics, quantum optics and solid state quantum theory. It also offers an introduction to quantum information, ultracold gases and photonics. The strong theory-experiment interlink I this research area is supported by the possible embedding of focused experimental guest lectures into the course.
Selection of topics:

- Introduction: 1-particle and many-body Schrödinger equation, spin and its physical consequences, fermions and bosons, Green functions
- Quantum many-body theory: creation and annihilation operators, observables, quantum field theory, applications (interacting Fermi gas, interacting Bose gas, ultra-cold quantum gases, 4He), coherent states, path integrals
- Quantum theory of the electromagnetic field: classical Maxwell field, Lagrange and Hamilton formalisms, quantization of the electromagnetic field, interaction of the electromagnetic field with matter, Casimir effect, Rayleigh and Thomson scattering, Raman effect
- Quantum optics: photon statistics, photon antibunching, coherent states, squeezed light, number states, atoms in cavities, quantum information (cryptography, computing, teleportation)
- Methods and models of quantum optics: coherent interactions, Jaynes-Cummings model, operators, operator identities and basis states, quantum statistics, characteristic functions, quasi-probability distributions, dissipative processes, spin-boson model, master equations, dressed states.

Modul 175	**Theoretical quantum optics and many body physics**	**08.128.175**

Literature

- F. Schwabl, Quantenmechanik für Fortgeschrittene, Springer-Verlag, Berlin, 1997.
- J. J. Sakurai, Advanced Quantum Mechanics, Addison Wesley, Reading, 1967.
- S. M. Barnett, P.M. Radmore, Methods in Theoretical Quantum Optics, Oxford Univ. Press, Oxford, 2002.
- M. Fox, Quantum Optics, Oxford Univ. Press, Oxford, 2006.
- M. A. Nielsen, I. L. Chuang, Quantum Computation and Quantum Information, Cambridge Univ. Press, Cambridge, 2000.
- M. Lewenstein, A. Sanpera, V. Ahufinger, Ultracold atoms in optical lattices, Oxford Univ. Press, Oxford, 2012.
- J. W. Negele, H. Orland, Quantum Many-particle Systems, Perseus Books, New York, 1994.
- R. Loudon, The Quantum Theory of Light, Oxford Univ. Press, Oxford, 2000.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	9/120
Module frequency	Annually in winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. P. van Dongen, Prof. Dr. P. van Loock
Applicable to the following programs	M.Sc. Physics, M.Sc. Mathematics
Miscellaneous	Course language: English

Modul 180	**Theoretical solid state physics**				**08.128.180**
Compulsory or elective module	**WP**				
Credit points and workload	**9 LP = 270 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Theoretical solid state physics" (WP)		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

Students will get acquainted with basic and advanced concepts and methods of theoretical solid state physics. They will learn fundamentals concepts of the atomic and electronic structure theory of solids that explain the stability of matter, how the symmetries of crystals govern many properties of matter, the dynamics and transport of electrons in solids, the basic optical properties of solid matter, and the basic concepts behind broken symmetry ordered states of solid matter such as magnetism and superconductivity. The class will provide the basic knowledge to prepare students for more advanced classes in solid state theory and for conducting a master thesis in Condensed Matter Theory or Experiment.

Course content

Basic Drude and Summerfeld theory of metals, Crystal symmetries, Reciprocal lattice, Theory of experimental determination of crystals, Crystal binding, Phonons, Free Electron gas, Bloch's theorem and the band structure of solids, Methods for calculating band structure, Fermi surface, Classification of conductors and semiconductors, Effects of electron-electron interactions, basic theory of transport and optical properties of solids, Introduction to basic ordered phases of solids such as magnetism and superconductivity.

Literature

- Charles Kittel: Introduction to Solid State Physics, Wiley
- Michael P. Marder, Condensed Matter Physics, Wiley
- Neil W. Ashcroft and N. David Mermin: Solid State Physics, Saunders College

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	9/120
Module frequency	At least once per year
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Sinova
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

3.3 Laboratory Courses and Seminars

Modul 620	**Advanced Laboratory**					**M.08.128.620**
Compulsory or elective module	**WP**					
Credit points and workload	**10 LP = 300 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Laboratory Project 1 (P)	Pr	2	P	4 SWS	108 h	5 LP
b) Laboratory Project 2 (P)	Pr	2	P	4 SWS	108 h	5 LP
To complete the module, the following achievements must be made:						
Presence	Pr					
Active participation						
Course achievements						
Module examination	Portfolio of the projects in part 1 respectively part 2					
Qualification and program goals / Competences						
This modul shall lead the students to advanced experimental and numerical-theoretical work in modern physics. At the same time they should get insight in the actual reseach activities at the institute. This is realized in the form of challenging projects in a research group of free choice and under the supervison of experienced assistants. Compared to the bachelor advanced laboratory course there is a stronger emphasis on independent work and actual research.						
Course content						
The format of these projects is quite flexible with respect to topic, implementation and timing. However it must be approved by the course convenor. Mandatory requests are that the topic includes modern physics, the duration does not exceed 60h of lab work, and that there is no thematic overlap neither with the bachelor thesis nor the other project in this module. Projects can be performed in all research groups with a focus on modern physics. Research at external institutions (e.g. major research institutions) is possible.						
Literature						
Specific literature and manuals from the project organizer						
Entry requirements						
Recommended prerequisites						
Language	Course language German/English Examination language German/English					
Weighting of the achievement in the overall grade	10/120					
Module frequency	Every semester					
Reasons for compulsory attendance						
Persons responsible for this module	Prof. Dr. W. Gradl					
Applicable to the following programs	M.Sc. Physics					
Miscellaneous						

Modul 630	**Seminars**					**M.08.128.630**
Compulsory or elective module	**WP**					
Credit points and workload	**8 LP = 240 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Seminar 1 (P)	HS	1	P	2 SWS	99 h	4 LP
b) Seminar 2 (P)	HS	1	P	2 SWS	99 h	4 LP
To complete the module, the following achievements must be made:						
Presence	HS					
Active participation	according to §5 subsection 3					
Course achievements						
Module examination	The students's presenations are graded both for seminar 1 and seminar 2					

Qualification and program goals / Competences

The goal of the seminars is to learn and practice giving presentations on topical physics areas. Specifically, the students should

- learn and practice presentation techniques and
- to discuss the physics contents.

Seminar 2 should include a deepened examination and discussion of up-to-date questions in physics research.

Course content

a) Student presentations of topics from a broad spectrum of current experimental and theoretical physics.

b) Student presentations on up-to-date topics relevant to the experimental or theoretical working groups of the physics institutes. Usually,several subjects will be offered to choose from with focus on atomic physics, condensed matter, nuclear and particle physics.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	8/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. W. Gradl
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

3.4 Topical Courses

3.4.1 Condensed Matter Physics

Modul 720	**Module Topical Courses: "Selected topics in Condensed Matter Physics"**					**08.128.720**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Selected topics in Condensed Matter Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Students shall be guided towards a selection of special problems in modern Condensed Matter Physics to obtain a solid background when dealing with research related topics. Magnetism and super conductivity emerge through the correlated dynamics of electrons in solids and provide the basis of modern electronics and information technology. Surface Science is essential for an in depth understanding of miniaturized devices as well as for novel diagnostic techniques. Soft Matter shows fascinating structural and dynamic properties and nurtures a rapidly developing field of applications. Its fundamental scientific questions also related to other disciplines like biology, chemistry and medicine. By an depth treatment of one or more of these topics, the course will provide a solid basis for conducting a master thesis in the area of Condensed Matter Physics.

Course content

Depending on the lecturer, the course will focus on specific topics, such as magnetism, super conductivity, heavy fermions, applied solid state physics, surface science or soft matter physics

Literature

will be provided by the lecturer

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Each summer semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. T. Palberg, Prof. Dr. M. Kläui
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul AdvCM	**Advanced Solid State Physics**				**08.128.22075**
Compulsory or elective module	**WP**				
Credit points and workload	**6 = 180**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced condensed matter physics"		2 (1)			138 h	6 LP
	V		P	3		
	Ü			1		
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination						

Qualification and program goals / Competences

After completing the module, students will be able to:

(a) understand and interpret the experimental data obtained using various thermodynamic, transport and spectroscopic methods, and

(b) describe the electrical, magnetic and optical properties of different classes of materials such as metals, semiconductors, insulators, as well as systems with macroscopic orders, such as (anti-)ferromagnets, superconductors, multiferroics, etc.

In addition, students will become familiar with the basic classical and quantum mechanical models of solid-state physics. The knowledge gained should form the basis for understanding the functional properties of the materials as they are used in everyday electronics, spintronics and future quantum technologies.

Course content

- Solid state physics in a nutshell (electronic band structure, phonon dispersion, properties of metals/semiconductors/insulators)
- Dielectric properties (electrodynamics, Lindhard response function, optical conductivity, Kramer-Kronig relationships, optical transitions and excitations, spectroscopy)
- Dielectrics/ferroelectrics (polarizability, displactive phase transitions, Ginzburg-Landau theory)
- Superconductivity (fundamental properties, Ginzburg-Landau theory of superconductivity, Abrikosov lattice, microscopic BCS theory, Josephson effect + SQUID, unconventional superconductivity)
- Density wave systems (charge/spin density waves and their collective modes)
- Magnetism (Anti-/Ferromagnetism)
- Topological quantum matter (Berry phase, topological phases, skyrmions, quantum spin fluids)
- Non-equilibrium phenomena (collective mode dynamics, driven phase transitions)

Literature

- Ashcroft, Mermin: Solid State physics;
- Gross, Marx: Festkörperphysik;
- Dressel, Grüner: Electrodynamics of Solids;
- selected scientific publications and reviews

Entry requirements	Experimental Physics 1-3, Condensed Matter Physics (Ex-C)
Recommended prerequisites	Experimental Physics 1-3, Condensed Matter Physics (Ex-C)
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/180
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Demsar

Modul AdvCM	**Advanced Solid State Physics**	**08.128.22075**
Applicable to the following programs	B.Sc. and M.Sc. Applied Physics, MSc Physics	
Miscellaneous		

Modul 721	**Module Topical Courses: " Modern Experimental Methods in Condensed Matter Physics"**				**08.128.721**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Modern Experimental Methods in Condensed Matter Physics" (WP)		1 (2)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Students shall be guided towards both fundamental facts and special aspects of state-of-the-art experimental methods in material science. The course will therefore present important and state of the art techniques and approaches. Examples may include spectroscopic methods, scattering techniques, scanning probe techniques as well as application related characterization of novel materials, sample preparation and conditioning techniques. Dealing with one or more of such topics, the course will develop an enhanced understanding of a research related area of expertise in Condensed Matter Physics. It will further provide a solid basis for conducting a master thesis in Condensed Matter Physics in this or a related area.

Course content

Depending on the lecturers, the course will focus on specific topics such as spectroscopic methods, scattering techniques, modern microscopy techniques, scanning probe techniques, synthesis strategies, sample preparation techniques or methods for material characterization under application related conditions.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every winter semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. T. Palberg, Prof. Dr. M. Kläui
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 722	**Module Topical Courses: “ Materials Science”**					**08.128.722**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises “Materials Science” (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Students shall be guided towards the essential physics of Material Science that is necessary for an understanding of processes in novel materials on the atomic and the nano-scale. Topics of interest covered by the course are, for example, the structure and properties of functional materials, nanomaterials, fluids and soft materials, glasses, functionalized surfaces, formation of and transitions within solids, modern methods of material science, as well as concepts and fundamentals of novel materials including their development and application. Dealing with one or more of such topics, the course will develop an enhanced understanding of a research related area of expertise in Condensed Matter Physics. It will further provide a solid basis for conducting a master thesis in Condensed Matter Physics in this or a related area.

Course content

Depending on the lecturer, the course will focus on specific topics like e.g. functional materials, nano materials, soft matter materials, glasses, functionalized sufaces, development strategies, characterization methods, phase transitions or materials for specific applications

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. T. Palberg, Prof. Dr. M. Kläui
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 7012	**Module Topical Courses: " Introduction to Advanced Materials - from soft matter to hard matter"**				**08.128.7012**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Introduction to Advanced Materials - from soft matter to hard matter" (WP)		1 (2)	WP		138 h	6 LP
Lecture	V			3 SWS		
Excercises	Ü			1 SWS		

To complete the module, the following achievements must be made:	
Presence	
Active participation	according to §5 subsection 3
Course achievements	successful completion of exercises or projects
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation

Qualification and program goals / Competences

Students will be introduced to the fundamentals of physics and chemistry of hard and soft matter. In particular, an understanding of how the size, nanoscopic arrangement and interaction energy of the atomic, molecular and macromolecular or colloidal building blocks determine the material properties will be achieved. Scattering is introduced as a universal method of analysis, which is suitable for the investigation of both hard and soft matter. For soft matter, an introduction to rheology is also given. One or more special topics are used to gain a deeper understanding of a research-related special field of condensed matter, which provides a good basis for successfully completing a Master's thesis.

Course content

- Introduction to crystal structures, lattice vibrations and lattice defects.
- Introduction to soft matter including polymers
- Introduction to scattering with photons, neutrons and electrons to study crystals, polymers and magnetic systems
- Introduction to rheology of polymers
- Introduction to magnetism

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every year
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Kläui
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 7014	**Module Topical Courses: “ Quantum Spintronics”**					**08.128.7014**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises “Quantum Spintronics” (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The students should be introduced to the physical fundamentals of magnetism from classical macroscopic descriptions to quantum mechanical single spin. In particular, an understanding of how individual electrons in the solid lead to macroscopic magnetisation through exchange coupling is to be achieved. The dynamics of spins is discussed classically as well as quantum mechanically and methods for measurement are explained. On the application side, energy-saving magnetoelectronics for memory, sensing and logic are introduced and spin-based qubits are explained. Students will understand the concepts of emergent phenomena and the transition from classical and quantum mechanical effects in the example of spin and be able to assess the application potential. Using one or more specific topics, students will gain a deeper understanding of a research-related special field of condensed matter, which is a good basis for being able to successfully complete a Master’s thesis.

Course content

Single spins and resulting magnetic moments, spin ensembles and thermodynamic effects, coupling of spins, spin dynamics, micromagnetism, spin torque effects, spin transport and magnetoresistance effects, realisation of QuBits with spins, measurement methods for spins, applications of spin.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Kläui
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 7013	**Module Topical Courses: "Superconductivity"**				**08.128.7013**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Superconductivity" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The students should get acquainted with the physical foundations of superconductivity. In particular they should understand how the independent individual electrons in a solid condense into a macroscopic quantum state, what is the symmetry of the order parameter, and how the order parameter is determined. An understanding of the transport properties of the superconducting ground state shall be achieved with respect to the possibilities of dissipation free transport and the realization of superconducting quantum phenomena as ultrasensitive sensors or qubits. In one or several special topics a deeper understanding of a subfield of current research in solid state physics shall be achieved forming the foundation to successfully prepare a master thesis on these topics.

Course content

Electrons in solids, BCS-theory for Cooper pair formation and condensation in the ground state, phase transition and transport properties Ginzburg-Landau description, type I and type II superconductors, the Josephson effect and its applications in ultra sensitive sensors and as voltage normal, critical currents in superconductors, superconducting magnets, superconducting qubits, high temperature superconductivity, transport in two-dimensional systems, related quantum effects as Quantum Hall effect.

Literature

Specialized textbooks of condensed mmatter physics, textbooks of superconductivity, Tinkham: Introduction to Superconductivity; Kleiner+Buckel: Superconductivity, specialized materials, summer school lectures, research papers

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Generally every year
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. G. Jakob, Prof. Dr. M. Jourdan
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 752	**Module Topical Courses: "Nonequilibrium phenomena in quantum matter"**					**08.128.752**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Nonequilibrium phenomena in quantum matter" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

This module addresses non-equilibrium phenomena in advanced solids, with focus on systems exhibiting low temperature macroscopic quantum states like superconductivity, charge/spin density waves, ferro- and antiferromagnetism. These states can be studied and manipulated by femtosecond optical pulses using the so-called "pump-probe" approach. Femtosecond technology and spectroscopy have experienced major developments in the recent two decades, providing means to femtosecond switching of magnetization, observations of Higgs modes in superconductors and light-induced enhancement of superconductivity, or making molecular movies, just to mention a few.
After introducing the general principle of the "pump-probe" spectroscopy, we will address several case studies, where different experimental techniques (THz spectroscopy, ultrafast electron diffraction, time-resolved ARPES, etc.) will be applied to study one of the above-mentioned macroscopic quantum states. This way we will learn the basics of non-linear optics, the novel laser-based techniques (used both in the lab and at large-scale facilities) and address physics of different material classes with fascinating functional properties.
The module should provide a broad overview of techniques and nonequilibrium phenomena in correlated solids, and thus present solid grounds for M.Sc. work in several areas of research in solid state physics.

Course content

Basics of nonlinear optics & ultrafast lasers; Principles of femtosecond real-time spectroscopy and modulation techniques; Femtosecond thermo-modulation in metals; Terahertz generation and THz time-domain spectroscopy; Basics of superconductivity; Electrodynamics of systems with broken symmetry ground states; Dynamics of the superconducting gap; Microwave enhancement of superconductivity; Collective (Higgs) modes in superconductors; Basics of Charge and Spin density waves; Time-resolved photoelectron spectroscopy; Femtosecond X-ray and electron diffraction – making molecular movies; Magnetization dynamics and switching

Literature

B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics, Wiley, 1991; Kittel: Introduction to Solid State physics; M. Dressel and G. Grüner: Electrodynamics of Solids; S. Blundell: "Magnetism in Condensed Matter"; Oxford Master Series in Physics; M. Tinkham: Introduction to Superconductivity; G. Grüner: Density waves in solids; selected scientific publications & reviews

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Normally every third semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Demsar

Modul 752	**Module Topical Courses: "Nonequilibrium phenomena in quantum matter"**	**08.128.752**
Applicable to the following programs	M.Sc. Physics	
Miscellaneous	Course language: English	

Modul 723	**Module Topical Courses: "Introduction to Condensed Matter Theory"**					**08.128.723**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Introduction to Condensed Matter Theory" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Building on the introductory courses on quantum mechanics and statistical thermodynamics, the central concepts of the description of crystalline solids shall be discussed. Starting from lattice periodicity and crystal symmetry, concepts like the electronic structure (electrons in a crystal field potential) and elementary excitations (phonons, magnons, plasmons, etc.) and their consequences for the various physical properties of solids at low temperatures are explained, thereby creating a solid basis to deal with research-related topics in the field of condensed matter theory.

Course content

Crystal structure, symmetry, the concept "reciprocal lattice", lattice dynamics in the harmonic approximation, relation to the elastic constants, electrons in a crystal field (Bloch wave and Wannier functions, energy bands, etc.), basic concepts of magnetism, magnons, etc. Also, depending on the choice of the lecturer, selected advanced topics (e.g., scattering theory of solids, electron-phonon interaction, plasmons and dielectric response, etc.) are presented.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every summer semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. P. van Dongen
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 724	**Module Topical Courses: "Selected Chapters of Condensed Matter Theory"**				**08.128.724**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Selected Chapters of Condensed Matter Theory" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Building on the foundations of statistical thermodynamics and/or quantum mechanics of many-body systems, the students will be introduced to specific aspects of the theory of quantum many-particle systems ("hard"condensed matter). Topics to be treated may include the theory of correlated fermions, modern static and dynamic phenomena of magnetism, low-dimensional systems, disorder, quantum phase transitions, many-body theory and their numerical methods, the theory of superfluidity and superconductivity, and topological quantum matter. Having completed this course, the student should have achieved a deeper understanding and a research-level specialization of condensed matter theory, which should form a solid foundation to successfully complete a master's thesis in a related field of physics.

Course content

Depending on the lecturer, the lecture may be focused on numerical methods in many-body physics, the theory of correlated fermions, the theory of superconductivity, modern magnetism, or topological systems.

Literature

- J. P. Hansen, I. R. McDonald, Theory of Simple Liquids, Academic Press, London 2006;
- J. Yeomans, Statistical Mechanics of Phase Transitions, Clarendon Press, Oxford, 1992;
- A. Onuki, Phase Transition Dynamics, Cambridge University Press, Cambridge, 2002;
- K. Binder, W. Kob, Glassy Materials and Disordered Solids. An Introduction to Their Statistical Mechanics, World Scientific, Singapore, 2005;
- W. Paul, J. Baschnagel, Stochastic Processes, From Physics to Finance, Springer, Berlin, 2000;
- A. Auerbach, Interacting Electrons and Quantum Magnetism, Springer (1994);
- P. Fulde, Electron Correlations in Molecules and Solids, Springer (1995);
- L. Kantorovich, Quantum Theory of the Solid State: An Introduction, Kluwer (2004);
- D.C. Mattis, The Theory of Magnetism Made Simple: An Introduction to Physical Concepts and to Some Useful Mathematical Methods, World Scientific, 2006;

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every summer semester
Reasons for compulsory attendance	

Modul 724	**Module Topical Courses: "Selected Chapters of Condensed Matter Theory"**	**08.128.724**
Persons responsible for this module	Prof. Dr. P. van Dongen	
Applicable to the following programs	M.Sc. Physics	
Miscellaneous	Course language: English	

Modul 725	**Module Topical Courses: "Theory of Soft Matter I"**				**08.128.725**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Theory of Soft Matter I" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The students become acquainted with the statistical description of systems with large fluctuations for the example of various soft matter systems. A special focus lies on general principles that may be applied for different material classes.

Course content

General concepts: Modeling, symmetry, and conservation laws, scattering laws, self similarity and scale invariance, mean-field approaches and Landau theories, Brownian dynamics, Critical dynamics;
Structure: Polymers (random walk, self-avoiding walk, blob concept, Flory screening, Flory Huggins theory, Path integral description of polymers, polymer field theory), Membranes (fluid, hexatic and crystalline membranes), Landau-de Gennes theory of liquid crystals;
Dynamics: Polymers (Rouse model), hydrodynamics at low Reynolds numbers, and (possibly) active and nonequilibrium matter.

Literature

- de Gennes, Scaling Concepts in Polymer Physics
- Doi/Edwards, The Theory of Polymer Dynamics
- Grosberg/Khokhlov, Statistical Mechanics of Macromolecules
- Chaikin/Lubensky, Principles of Condensed Matter Physics
- Russel/Saville/Schowalter, Colloidal Dispersions
- Dhont: An introduction to the dynamics of colloids

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Upon request
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. K. Kremer, Prof. Dr. F. Schmid
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 745	**Module Topical Courses: "Modern Computational Techniques in Condensed/Soft Matter Physics"**					**08.128.745**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Modern Computational Techniques in Condensed/Soft Matter Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					
Qualification and program goals / Competences						
Students attending the course will learn the use of advanced tools and techniques for efficiently performing computer simulations in the field of condensed and soft matter physics, possibly including molecular biophysics. These techniques will enable them to study phenomena like phase transitions in a variety of systems (liquids, solids, polymer melts etc.), conformational changes, chemical reactions, non-equilibrium or driven phenomena etc.						
Course content						
The topics of the course will be selected according to the docent and can include free energy calculations, enhanced sampling techniques, simulation of rare events, critical phenomena, non-equilibrium dynamics, coarse-graining, density functional theory, force-field optimization, polarizable force fields, long range interactions, etc.						
Literature						
To be announced in class						
Entry requirements						
Recommended prerequisites						
Language	Course language English Examination language English or German					
Weighting of the achievement in the overall grade	6/120					
Module frequency	At least once per year					
Reasons for compulsory attendance						
Persons responsible for this module	Prof. Dr. F. Schmid					
Applicable to the following programs	M.Sc. Physics, Master "Computational Sciences" with focus on physics					
Miscellaneous	Course language: English					

Modul 801	**Module Topical Courses: "Computer Simulations in Statistical Physics"**				**08.128.801**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Computer Simulations in Statistical Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Students will learn to describe complex physical problems in terms of simple models, to translate these into algorithms, and to implement the algorithms correctly and in an efficient way on modern computer architectures. They will learn to appreciate the importance of computer simulations in their interaction with theory and experiment.

Course content

Molecular dynamics simulations, symplectic integrators, Markov chain Monte Carlos, random number generators, analysis of time series, finite size effects and simulations in different thermodynamic ensembles.

Literature

- D. Frenkel, B. Smit, Understanding Molecular Simulation – From Algorithms to Applications, Academic Press, San Diego, 2002
- D. P. Landau, K. Binder, A Guide to Monte Carlo Simulations in Statistical Physics, Cambridge University Press, New York, 2005
- M. P. Allen, D. J. Tildesley, Computer Simulations of Liquids, Clarendon Press, Oxford, 1987
- J. M. Haile, Molecular Dynamics Simulations – Elementary Methods, Wiley, New York, 1997.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every winter semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. F. Schmid
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 7010	**Module Topical Courses: "Soft Materials at Interfaces"**					**08.128.7010**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Soft Materials at Interfaces" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The course gives an introduction to the physical principles to understand the structure and dynamics of soft condensed matter adjacent to solid, liquid, and vapor interfaces. Soft matter interfaces are ubiquitous in life and technology, see for example, OLED displays on smartphones, soap bubbles, many biological tissues.
Particular emphasis is given to the links connecting intermolecular forces with molecular scale structure and physical materials properties. The course further introduces the experimental techniques required to study soft matter interfaces on the relevant time and length scales. Focus is set to scattering and scanning probe techniques, providing complementary information in real and reciprocal space.
The course will enable the students to understand numerous physical phenomena surrounding us in everyday live while also providing them with the basic knowledge for improving the performance of modern soft materials for specific applications. Examples help to develop a deeper understanding and to explore links to other branches of physics.

Course content

Topics may vary depending on the preferences of the lecturers. Typical topics are

- Thermodynamics of interfaces
- Surface tension
- Self-organization of soft matter thin films
- Charged solid/liquid interfaces and Helmholtz double layer
- Interfacial forces and colloidal stability
- Interface induced phase transitions
- Adsorption and wetting
- Surfactants and Emulsions
- Interfacial freezing and premelting
- Liquids in nanoporous materials
- X-ray scattering and spectroscopy
- Scanning probe techniques and force measurements

Literature

- Metin Tolan, "X-Ray Scattering from Soft-Matter Thin Films", Springer (1999).
- Jens Als-Nielsen, Des McMorrow, "Elements of Modern X-ray Physics", 2nd Edition, Wiley (2011).
- Peter S. Pershan , Mark Schlossman, "Liquid Surfaces and Interfaces : Synchrotron X-ray Methods", Cambridge University Press (2012).
- Hans-Jürgen Butt, Karlheinz Graf, Michael Kappl, "Physics and Chemistry of Interfaces", 3rd Edition, Wiley (2013).

Entry requirements	
Recommended prerequisites	

Modul 7010	**Module Topical Courses: "Soft Materials at Interfaces"**	**08.128.7010**
Language	Course language English Examination language English or German	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Annually	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Hans-Jürgen Butt, Prof. Dr. Thomas Palberg, Prof. Dr. F. Schmid	
Applicable to the following programs	M.Sc. Physics	
Miscellaneous	Course language: English	

Modul 753	**Module Topical Courses: "Biophysics"**					**08.128.753**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Biophysics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The course gives an introduction to phenomena in biological matter using concepts from theoretical physics in order to expose and understand common physical principles. Students will learn about the elementary molecular components of a cell, as well as the interactions of these components and the formation of hierarchical functional structures. The course will enable students to understand and approach phenomena in biological systems from a physics perspective. Particular attention is given to the application of established concepts from soft matter physics and their application to living matter.

Course content

There will be an introduction to living matter (tissue, bacteria, cells, etc.) and its organization, as well as the molecular players (proteins, polymers, enzymes). Further topics may vary depending on the preferences of the lecturers. Typical topics include:

- Stochastic dynamics, diffusion, and single molecule dynamics
- Basics of non-equilibrium thermodynamics and information theory
- Physical limits to sensing
- Biochemical networks and criticality
- Mechanochemical coupling, molecular motors and force generation
- Collective behavior and phase behavior
- Self-organization and structure formation
- X-ray scattering and the structure of proteins
- Membranes and their theoretical description

Literature

- William Bialek, Biophysics: Searching for Principles, Princeton University Press (2013).

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Thomas Speck, Prof. Dr. Friederike Schmid
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 754	**Module Topical Courses: "Advanced theoretical solid state physics"**				**08.128.754**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced theoretical solid state physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Students shall get acquainted with basic and advanced concepts and methods of theoretical solid state physics. They will learn fundamentals concepts of electronic structure theory that explain the stability of matter, of symmetries that govern many structural properties of matter, of transport mechanisms, and of the role of excitations and defects for many material properties in solid matter. The class will provide basic knowledge to prepare them for more advanced classes in solid state theory and for conducting a master thesis in Condensed Matter Theory or Experiment.

Course content

Crystal symmetries, Reciprocal lattice, Phonons, Electron gas, Band structure, Methods for calculating Band Structure, Fermi surface, Conductors and Semiconductors, Quasiparticles concepts, Defects and Disordered systems, Transport, Optical properties, Magnetism, Superconductivity

Literature

- Ashcroft, Mermin: Solid State Physics, Saunders College
- Kittel: Quantum Theory of Solids, Wiley
- Jones, March, Theoretical Solid State Physics, Vol 1,2, John Wiley
- Ziman, Principles of the Theory of Solids, Cambridge University Press

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Each summer semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Sinova
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 800	**Module Topical Courses: "Theory of Soft Matter II"**	**08.128.800**
Compulsory or elective module	**WP**	
Credit points and workload	**6 LP = 180 h**	
Duration according to the study plan	**1**	

Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Theory of Soft Matter II" (WP)		2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		

To complete the module, the following achievements must be made:	
Presence	
Active participation	according to §5 subsection 3
Course achievements	successful completion of exercises or projects
Module examination	Written exam (90-180 Min.) or oral examination (30 Min.)

Qualification and program goals / Competences

The students get acquainted with the statistical description of systems with large fluctuations, given the example of different soft matter systems. Special focus lies on general principles which can be applied for different material classes.

Course content

Topics are selected depending on the preferences of the lecturers. Possible topics are: DLVO theory, hydrodynamic interactions in colloids and polymers, micro swimmers and active particles, Zimm model, reptation model, networks and rubber elasticity, structure of polyelectrolytes, viscoelasticity, materials science aspects of soft matter systems, statistical physics of interfaces, wetting, capillary waves.

Literature

- de Gennes, Scaling Concepts in Polymer Physics
- Doi/Edwards, The Theory of Polymer Dynamics
- Grosberg/Khokhlov, Statistical Mechanics of Macromolecules
- Chaikin/Lubensky, Principles of Condensed Matter Physics
- Russel/Saville/Schowalter, Colloidal Dispersions.
- Dhont: An Introduction to Dynamics of Colloids

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. K. Kremer, Prof. Dr. F. Schmid
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

3.4.2 Quantum, Atomic and Neutron Physics

Modul Q-Ex-1	**Module Topical Courses: "Quantum Optics (Q-Ex-1)"**				**08.128.729**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Quantum Optics" (WP), frequently joint theoretical-experimental course		1 (2)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The students shall be introduced to the principles of the quantized description of radiation fields. Theoretical methods shall be discussed along with selected experiments which demonstrate effects of quantized radiation fields.

Course content

Basic entry course to experimental quantum optics. Interdisciplinary experiment-theory course, frequently lectured jointly by experimentalists and theorists.
Contents:

- Quantization of electromagnetic fields, quantum states of radiation fields
- correlations in the radiation field and in photon statistics
- quantized interaction of atoms with light, Jaynes-Cummings Hamiltonian
- "dressed states"

Further possible topics:

- Photon detectors
- single photon sources and entangled photons
- Bell equations, quantum mechanical correlations of entangled photon pairs
- cavity quantum electrodynamics

Literature

Textbooks on quantum optics and light-atom interaction,

- Introductory quantum optics, Gerry & Knight
- The Quantum theroy of light, Loudon
- Quantum optics, Scully & Zubairy
- Quantum optics, Walls & Milburn
- Atom photon interactions, Cohen-Tannoudji, Dupont-Roc & Grynberg

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120

Modul Q-Ex-1	**Module Topical Courses: "Quantum Optics (Q-Ex-1)"**	**08.128.729**
Module frequency	Every winter term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. J. Walz	
Applicable to the following programs	M.Sc. Physics	
Miscellaneous	Course language: English	

Modul Q-Ex-2	**Module Topical Courses: "Photonics (Q-Ex-2)"**				**08.128.803**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Photonics" (WP)		2 (1)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The students shall be introduced to the advanced description of light propagation and the interaction with matter. A deep understanding of laser spectroscopy – based on incoherent and coherent licht-matter interaction and highly stable lasers shall be acquired; in particular the difference between coherent and incoherent processes will be detailed. The students should learn to understand the working principle of lasers and fundamentals of non-linear optics.

Course content

Fundamentals of experimental quantum physics. Possible topics:

- Gaussian optics and resonators
- connection between classical, semi-calssical and quantum mechanical description of light-matter interaction
- coherent light and lasers
- laser modulators, optical fibers
- short pulses and frequency comb techniques
- incoherent spectroscopy techniques (absorption, fluorescence, Doppler-free, frequency modulation)
- comparison with coherent techniques (Rabi, Ramsey, Spin-Echo)
- non-linear media, sum- and difference frequency generation, $\chi^{(2)}$ vs. $\chi^{(3)}$ processes,
- laser cooling

Literature

Specialized textbooks in photonics , e.g.

- Laser Spectroscopy, W. Demtröder
- Optics, Light and Lasers, D. Meschede
- Lasers, A.E. Siegman
- Fundamentals of Photonics, B. E. A. Saleh und M.C. Teich
- publications close to current research.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every summer term
Reasons for compulsory attendance	

Modul Q-Ex-2	**Module Topical Courses: "Photonics (Q-Ex-2)"**	**08.128.803**
Persons responsible for this module	Prof. Dr. K. Wendt, Prof. Dr. J, Walz	
Applicable to the following programs	M.Sc. Physics	
Miscellaneous	Course language: English	

Modul Q-Ex-3	**Module Topical Courses: "Quantum Information (Q-Ex-3)"**				**08.128.804**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Quantum Information " (WP), frequently joint theoretical-experimental course		2 (1)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Based on their knowledge of atomic and quantum physics as well as quantum mechanics, the students will study and derive the basic theoretical concepts of quantum information processing and quantum computing. On the experimental side, concepts, experimental realizations, platforms and applications of these concepts will be introduced involving the necessary aspects of quantum optics.

Course content

Advanced course in the field of quantum optics, atomic physics and its application to quantum information. "Stand-alone" course, applies concepts from Quantum Optics and many boy physics. Interdisciplinary course, frequently lectured jointly by experimentalists and theorists.
Contents:

- storage and processing to quantum information in different systems
- lead to quantum communication and computing
- entangled states, quantum jumps, quantum Zeno effect
- decoherence, macroscopical quantum superposition ("Schrödinger cat states")

Further possible topics:

- quantum gates and algorithms
- quantum cryptography, quantum teleportation, quantum repeaters
- error correction, error prone quantum processing
- quantum simulation
- Systems: ion trap, in particular Paul trap based quantum computers, cavity QED, linear optical quantum computers, neutral atoms in optical lattices, solid state and superconducting quantum processors.

Literature

Text books on quantum optics and quantum information processing, e.g.

- Introductory quantum optics, Gerry & Knight
- Quantum Computation and Quantum Information, Nielsen & Chuang
- Introduction to Quantum Computation and Quantum Information, Lo, Popescu & Spiller
- The Physics of Quantum Information, Bouwmeester, Ekert & Zeilinger
- Exploring the Quantum - Atoms, Cavities and Photons, Haroche & Raimond

Entry requirements	
Recommended prerequisites	

Modul Q-Ex-3	**Module Topical Courses: "Quantum Information (Q-Ex-3)"**	**08.128.804**
Language	Course language English Examination language English or German	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Every summer term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. F. Schmidt-Kaler	
Applicable to the following programs	M.Sc. Physics	
Miscellaneous	Course language: English	

Modul Q-Ex-4	**Module Topical Courses: "Precision fundamental physics (Q-Ex-4)"**				**08.128.805**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Precision fundamental physics" (WP)		1 (2)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

Current dedicated measurements have reached fascinating levels of experimental precision and can explore fundamental questions of physics and cosmology. These include: fundamental symmetries of physics, precision measurements in neutron decay, tests of the weak interaction, tests of CPT invariance, precision measurements of fundamental constants, and modern experiments in gravitation. The students shall be introduced to problems of modern atomic physics, quantum physics, neutron physics, and cosmology. The students shall profoundly deal with these topics, close to current research.

Course content

Discrete symmetries and fundamental interactions in physics

- tests of QED and CP violation, CPT-invariance, time reversal symmetry
- weak interaction, matter/ antimatter asymmetry, EDM
- variation of fundamental constants tests of the equivalence principle, Newton's gravitation law at short distances

Methods

- Atoms, neutrons, protons, antimatter, penning traps, mass spectrometry

Neutron Physics

- the neutron as probe – structure analysis of matter, properties of the neutron and measurements, interaction with matter, neutron sources, detectors, quantum effects in neutron optics

Literature

- Textbooks in atomics physics
- proceedings of summer-schools
- publications close to current research.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Walz
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

3.4.3 Nuclear and Particle Physics

Modul 730	**Module Topical Courses: "Statistics, Data Analysis and Simulation"**				**08.128.730**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Statistics, Data Analysis and Simulation" (WP) Lecture Excercises	 V Ü	2 (1)	WP	 3 SWS 1 SWS	138 h	6 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The module provides an overview of the statistical methods to analyze data and offers an introduction to Monte Carlo techniques. While the methods are often introduced with the help of examples taken from the areas of particle, hadronic and nuclear physics, we recommend the module also to students specializing in other fields. The goal of the course is to provide a solid basis that helps to successfully complete a master's thesis in a related area of physics.

Course content

The following areas shall be covered:

- Probability distributions and the statistical description of data;
- error propagations and the estimation of parameters;
- significance levels and decisions on hypotheses;
- Monte Carlo methods, as well as
- Statistical analysis methods.

Literature

- R.J. Barlow, Statistics
- Glen Cowan, Statistical data analysis
- Olaf Behnke, Data analysis in high energy physics

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every summer semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Schott
Applicable to the following programs	B.Sc. and M.Sc. Applied physics, M.Sc. Physics
Miscellaneous	

Modul 731	**Module Topical Courses: "Particle Detectors"**				**08.128.731**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Particle Detectors" (WP)		1 (2)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The module provides an overview of the detection, read-out and analysis techniques used in particle, hadron, nuclear, and astroparticle physics. The goal is to provide a solid basis for the successful completion of a master's thesis. Cross disciplinary aspects (solid state physics, electronics, mathematics, and computer science) play important roles. Therefore the course is also suitable to students that focus on other areas of physics.

Course content

The following subjects shall be covered:

- Particle sources and accelerators;
- Detection methods for charged and neutral radiation;
- Data acquisition;
- Particle detectors to measure time, energy, momentum and particle type;
- Applications in complex detector systems.

Literature

- K. Kleinknecht, Detectors for particle radiation
- C. Grupen, B. Shwartz, Particle Detectors

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every winter semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Schott
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 732	**Module Topical Courses: "Cosmology and General Relativity"**					**08.128.732**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Cosmology and General Relativity" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					
Qualification and program goals / Competences						
The lectures' program goal is to provide a basic understanding of the theory of General Relativity as well as of the current concepts and phenomena of cosmology.						
Course content						
General coordinate transformations, differential geometry, Einstein equation, Schwarzschild metric, black holes, Friedmann-Robertson-Walker cosmology, big-bang nucleosynthesis, cosmic microwave background, structure development in the early universe, dark matter and dark energy.						
Literature						
e.g. Carroll, Wald, Kolb & Turner, Dodelson						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Neubert
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 733	**Module Topical Courses: "Symmetries in Physics"**				**08.128.733**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Symmetries in Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					
Qualification and program goals / Competences						
The lectures' program goal is to provide a basic understanding of group theory and its' applications in physics.						
Course content						
Group theory, representations, unitary symmetries, Lie groups, applications and exercises in particle and nuclear physics.						
Literature						
e.g. Georgi, Tung						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Neubert
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 734	**Module Topical Courses: "Modern Methods in Theoretical High Energy, Particle and Nuclear Physics"**					**08.128.734**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Modern Methods in Theoretical High Energy, Particle and Nuclear Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The lectures' program goal is to provide a basic understanding of a topic related to current research in the field of high energy, particle and nuclear physics. An additional goal is to teach the methods which are required for the masters's thesis.

Course content

Concerning to the lecturer the focus is put on a current scientifical topic from the following research areas: electroweak and strong interactions, lattice gauge theory, effective field theories, mathematical aspects of perturbation theory, functional integration in quantum mechanics und quantum field theory, concepts of model building beyond the standard model (e.g. supersymmetry, string theory) and others. Lectures of this module are offered by different lecturers and topics can change every semester. In this case a student can subscribe to this module more than once and the module will not be counted as identical.

Literature

various textbooks, publications close to science

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Neubert, Prof. Dr. H. Wittig
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 735	**Module Topical Courses:"Accelerator Physics"**				**08.128.735**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Accelerator Physics" (WP)		1 (2)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The purpose of the lecture is to provide an understanding of the underlying physical principles of modern particle accelerators and radiation sources. This concerns in particular the layout of pivotal components such as magnetic structures and radiofrequency-systems. Another objective is to teach the mathematical framework with respect to analytical and numerical methods. Such knowledge will form a suitable basis for doing a master's thesis within the accelerator physics groups at Mainz university.

Course content

Linear and non linear beam-dynamics, in conjunction with properties of linear and recirculating accelerators. Building blocks of beam transport systems, e.g. normal und superconducting magnets. Radiofrequency systems for charged particle acceleration, including superconducting systems. Introduction to superconductivity. Introduction to radiation physics (Synchrotron-radiation), Collective effects, e.g. free electron laser. Recent developments such as energy recovery linacs.

Literature

- H. Wiedemann, Particle Accelerator Physics Bd. 1&2

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every winter semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. K. Aulenbacher
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 737	**Module Topical Courses: "Astroparticle Physics"**					**08.128.737**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Astroparticle Physics" (WP)		2 (1)	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The module provides an overview of cosmology and astroparticle physics and of topical research themes. It provides essential knowledge to successfully complete a master's thesis in a related subject area.

Course content

The main themes of the course relate to:

- Cosmology and the evolution of the Universe
- Dark matter and
- Cosmic radiation of charged particles, neutrinos, and gammas as well as gravitational waves.

The subject "cosmology and evolution of the universe" covers cosmological models and parameters, cosmological distances and related measurements, the matter/antimatter problem, the synthesis of light elements, the microwave background radiation, structure formation, the formation, classification, development of galaxies, active galactic nuclei and galaxy clusters, as well as the formation, energy budget, development, and final stages of stars, including the related nucleosynthesis. The theme "dark matter"covers the evidence, as well as direct and indirect searches performed to detect viable particle candidates. Keywords important for the chapter on "cosmic rays" are: sources, composition, propagation, and detection of charged cosmic radiation, sources and detection of resolved and diffuse gamma-ray sources, determination of neutrino properties (oscillations, direct mass measurement, neutrino-less double beta decay), sources and detection of terrestrial and astrophysical neutrinos, the theory and prospective sources of gravitational waves, as well as their indirect and direct detection.

Literature

- A. Liddle, An introduction to modern cosmology
- P. Schneider, Extragalaktische Astronomie und Kosmologie
- C. Grupen, Astroteilchenphysik
- D. Perkins, Particle Astrophysics

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every summer semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. U. Oberlack
Applicable to the following programs	M.Sc. Physics

Modul 737	Module Topical Courses: "Astroparticle Physics"	08.128.737
Miscellaneous	Course language: English	

Modul 738	**Module Topical Courses: "Particle Physics"**					**08.128.738**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Particle Physics" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The module is intended to deepen the understanding of the fundamental building blocks of matter and their interactions. Basic principles will be covered by using topical research as an example. The module provides the required knowledge in order to successfully complete a master's thesis in a related subject.

Course content

The following subjects shall be covered:

- Brief outline of experimental methods,
- Symmetries and the quark model,
- Lepton scattering at high energies,
- Particles and interaction in the Standard Model, as well as models for its unification and extension.

While covering the subjects, ground breaking and actual experiments will be discussed. Depending on the docent's interest, extension of the Standard Mode or bound systems will be covered in more detail.

Literature

- C. Berger, Elementarteilchenphysik, Springer-Verlag, 2006.
- D. Griffiths, Introduction to Elementary Particles, Wiley-VCH Verlag, 2008.
- E. Lohrmann, Hochenergiephysik, Teubner-Verlag, 2005.
- D. H. Perkins, High Energy Physics
- B. Povh et al., Teilchen und Kerne

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Schott
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 809	**Module Topical Courses: "Theoretical Particle Physics"**				**08.128.809**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Theoretical Particle Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					
Qualification and program goals / Competences						
The lecture course "Theoretical Particle Physics" builds upon and continues the lecture course "Relativistic Quantum Field Theory". The lectures' program goal is to provide a basic understanding of concepts and methods of quantum field theory which are required for a MA thesis in theoretical particle physics.						
Course content						
Path integral formalism, quantum corrections, renormalization in QED, renormalization group; non-Abelian gauge theories, quantum chromodynamics (QCD), spontaneous symmetry breaking, Higgs mechanism, standard model of particle physics.						
Literature						
Peskin & Schroeder, Ryder, Schwartz, Zee						
Entry requirements						
Recommended prerequisites						
Language	Course language English Examination language English or German					
Weighting of the achievement in the overall grade	6/120					
Module frequency	Usually every semester					
Reasons for compulsory attendance						
Persons responsible for this module	Prof. Dr. S. Weinzierl					
Applicable to the following programs	M.Sc. Physics					
Miscellaneous	Course language: English					

Modul 751	**Module Topical Courses: "Theoretical Nuclear Physics"**					**08.128.751**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Theoretical Nuclear Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The aim of this course is to provide students with a survey of nuclear theory at the graduate level, as well as an introduction to modern nuclear theories and topics. While the focus is on theoretical aspects of nuclear physics, when possible, the subject will be linked to recent experimental progress and applications, e.g. to astrophysics.

Course content

Introduction to nuclei and nuclear forces, Theory for alpha, beta and gamma decays, Types of nuclear spectra and EM transitions, Few-body methods for nuclei, Many-body methods for nuclei, Nuclear reactions, Nuclear astrophysics and formation of the elements.

Literature

Text books on nuclear physics, e.g.

- Samuel S.M. Wong, Introductory Nuclear Physics.
- Carlos A. Bertulani, Nuclear Physics in a Nutshell.
- Kenneth S. Krane, Introductory Nuclear Physics.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Winter semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. S. Bacca
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 746	**Module Topical Courses: "Introduction to Lattice Gauge Theory"**				**08.128.746**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Introduction to Lattice Gauge Theory" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The lectures' program goal is to provide a basic understanding of the methods of lattice gauge theory and its applications to problems in particle and nuclear physics. A particular goal is to teach the methods which are required for pursuing a master's thesis in this field.

Course content

Discretization of PDEs by finite differences; path integral in quantum mechanics; Euclidean correlation functions in QFT; transfer matrix; scalar field theories on the lattice and spin models; Ising model at high and low temperature; Z_2 lattice gauge theory, Elitzur's theorem and Wegner loop; QED and QCD in the continuum; Wilson loop; lattice gauge theory with Wilson action; Haar measure; fermions on the lattice; static potential and strong-coupling expansion; renormalization group and continuum limit; lattice perturbation theory; Monte Carlo simulations and determination of hadronic properties.

Literature

- C. Gattringer and C.B. Lang, Quantum Chromodynamics on the Lattice (Lect. Notes Phys. 788), Springer, Berlin Heidelberg 2010.
- J. Smit, Introduction to Quantum Fields on a Lattice: a robust mate (Cambridge Lect. Notes Phys. 15), Cambridge University Press 2002.
- I. Montvay and G. Münster, Quantum Fields on a Lattice, Cambridge University Press 1994.
- J.B. Kogut, An Introduction to Lattice Gauge Theory and Spin Systems, Rev. Mod. Phys. 51 (1979) 659.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. H. Wittig
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 760	**Module Topical Courses: "Introduction to String Theory"**					**08.128.760**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Introduction to String Theory" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The lectures' program goal is to provide a basic understanding of classical and quantised bosonic and fermionic string theories. An additional goal is to teach methods which are required for the maters's thesis.

Course content

Classical bosonic string, quantisation (lightcone, covariant, path integral, BRST formalism), D-branes, superstrings, introduction to conformal field theory, string amplitudes.

Literature

various textbooks, publications close to science, e.g.:

- Zwiebach: A First Course in String Theory, Cambridge University Press 2004;
- Blumenhagen, Lüst, Theisen: Basic Concepts of String Theory, Springer 2012;
- Polchinski: String Theory, Vol. 1 & 2, Cambridge University Press 1998;
- Green, Schwarz, Witten: String Theory, Vol. 1 & 2, Cambridge University Press 1987;
- Becker, Becker, Schwarz: String Theory and M-Theory - A Modern Introduction, Cambridge University Press 2007

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. G. Honecker
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 766	**Module Topical Courses: "Effective Field Theories"**				**08.128.766**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Effective Field Theories" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The lectures introduce the basic ideas of the effective field theory approach like relevant and irrelevant operators, renormalization group, decoupling of heavy particle. The lectures also provide a deeper understanding of its most important applications in modern research fields.

Course content

The method of effective field theory provides a systematic approach to multi-scale problems. An effective field theory uses the appropriate degrees of freedom to describe the phenomena at a given energy scale, while all degrees of freedom only relevant at much higher scales are eliminated from the theory. These concepts lead to a large variety of phenomenological applications in modern particle physics. Especially in the theory of strong interactions with its different behaviour at the various energy scales the important examples of the electroweak Lagrangian, heavy-quark-effective theory, and soft-collinear-effective theories allow for most suitable descriptions of the respective theoretical systems.

Literature

- Lecture notes Ëffective Field Theory"by A. Pich
- Lecture notes Ëffective Field Theories"by A. Manohar
- Lecture notes Ëffective Field Theories and Heavy Quark Physics"by M. Neubert

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Neubert
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 762	**Module Topical Courses: "Theoretical Astroparticle Physics"**					**08.128.762**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Theoretical Astroparticle Physics" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

This lecture aims to give, from a theorists point of view, a broad but thorough overview of state of the art astroparticle physics. Its goal is to prepare students to understand the current scientific literature on cosmology, dark matter, neutrinos and related topics and to prepare them for their own research projects (Master / PhD) in experimental or theoretical astroparticle physics.

Course content

The big bang theory (Friedmann equation, expansion of the Universe); big bang nucleosynthesis; cosmic microwave background; formation of structure in the Universe; dark matter (production in the early Universe by thermal freeze-out, searches in terrestrial and astrophysical experiments); the cosmic matter-antimatter asymmetry; high energy cosmic rays; neutrinos (mechanisms to explain the smallness of neutrino masses; theory and phenomenology of neutrino oscillations; impact of neutrinos on cosmology; supernova neutrinos); axions

Literature

various textbooks, publications close to science

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Kopp
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 764	**Module Topical Courses: "Amplitudes and Precision Physics at the LHC"**				**08.128.764**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Amplitudes and Precision Physics at the LHC" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The goal of this lecture is to introduce students to recently developed methods for calculating scattering amplitudes within quantum field theory. A particular emphasis is put on the efficiency of the methods to be used. These new methods allow to predict cross sections for the experiments at the LHC, which are difficult to compute with traditional methods.

Course content

Spin- and helicity methods, colour decomposition, off-shell recursion relations, on-shell recursion relations, scattering equations; loop integrals, differential equations for loop integrals, classes of functions (for example multiple polylogarithms).

Literature

- J. Henn, J. Plefka, „Scattering Amplitudes in Gauge Theories", Springer, 2014;
- H. Elvang, Y. Huang, „Scattering Amplitudes in Gauge Theory and Gravity", Cambridge University Press, 2015;
- L. Dixon, „Calculating Scattering Amplitudes Efficiently", arxiv.org/abs/hep-ph/9601359

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. J. Henn, Prof. Dr. S. Weinzierl
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 747	**Module Topical Courses: "Functional Methods and Exact Renormalization Group"**				**08.128.747**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Functional Methods and Exact Renormalization Group" (WP)		1	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (120-180 Min.), oral examination (30 Min.), term paper or presentation					

Qualification and program goals / Competences

The goal of this lecture is to introduce students to path integrals, functional integral quantization of field theories and the functional renormalization group equation.

Course content

(A) Path integrals in quantum mechanics:

- Relation to the canonical approach, discretization and operator ordering, topological aspects (multiply connected configuration spaces, etc.), evaluation of functional integrals (exactly soluble examples, semiclassical expansion, perturbation theory), instantons in quantum mechanics (double well, periodic potentials, n- and Theta-vacua).

(B) Functional integral quantization of field theories:

- Functional Schroedinger picture, wave functionals, field-particle relationship, symmetry and covariance properties, from transition amplitudes to (vacuum-) correlators and generating functionals, the Schwinger-Symanzik approach, functional integral representation via the Schroedinger picture and the Schwinger-Symanzik approach, the effective action (canonical and diagrammatic approaches, Legendre-Fenchel transform), computational techniques (semiclassical and perturbative expansion), perturbative Yang-Mills theory, nonperturbative Yang-Mills theory ("large"gauge transformations, homotopy classes- and groups, instantons and tunneling, nonperturbative vacuum structure).

(C) The functional renormalization group equation (FRGE):

- Functional (i.e. "exact") vs. perturbative renormalization, critical phenomena, Wilsonian renormalization group in statistical mechanics and quantum field theory (theory space, block spin transformations, coupling constant flows), notions of nonperturbative renormalizability, continuum limits and phase transitions, construction and "solution" of quantum field theories by means of FRGE methods.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Reuter
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 806	**Module Topical Courses: "Advanced Particle Physics"**				**08.128.806**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced Particle Physics" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (90-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

This course covers special aspects of the fundamental building blocks of matter and their interactions in detail. The newest experimental methods and results will be presented for topical research areas in particle physics. The course provides the students with advanced knowledge that will help in completing an experimental master's thesis in a related research area.

Course content

The content of the course is variable and will typically include one of the following subjects:

- Lepton scattering at high energies,
- Strong interaction,
- Electro-weak interaction, as well as
- Models for the unification and extrension of the Standard Model.

Literature

- C. Berger, Elementarteilchenphysik
- D. Griffiths, Introduction to Elementary Particles

Recommendations for specialized books and recent publication on current topics will be provided.

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Schott
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 807	**Module Topical Courses: "Advanced Chapters on Subatomic Physics"**					**08.128.807**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced Chapters on Subatomic Physics" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (90-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

The module intends to provide a deep understanding on research-oriented topics of hadron physics. Basic concepts as well as research topics will be presented. The module will provide the essential knowledge necessary to successfully complete an experimental master's thesis in related fields.

Course content

Current experimental methods, electromagnetic and hadronic probes, polarization experiments; resonances, decays, form factors and structure functions of hadrons; effective theories; spectroscopy, symmetry and structures of hadrons, the impact of hadron physics on precision tests of the Standard Model. Key experiments will be discussed for all topics.

Literature

Several text books, e.g.

- B. Povh et al., Teilchen und Kerne
- D. H. Perkins, High Energy Physics
- W. Thomas und W. Weise, The Structure of the Nucleon

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. A. Denig
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 808	**Module Topical Courses: "Advanced Astroparticle- and Astrophysics"**				**08.128.808**
Compulsory or elective module	**WP**				
Credit points and workload	**6 LP = 180 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced Astroparticle- and Astrophysics" (WP)		1 o. 2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (90-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

This module covers special aspects of astroparticle physics and astrophysics, thereby presenting the newest experimental methods and results. The module provides the students with advanced knowledge that will help in completing an experimental master's thesis in a related research area.

Course content

Depending on interest of the lecturer, the emphasis will be put on nuclear- or astrophysical aspects of the following subjects:

- Cosmology (early universe, nucleosynthesis, dark components),
- Stars (formation, energy production and development stages) or Cosmic radiation (origin, acceleration mechanisms, etc.).

Literature

- C. Grupen, Astroteilchenphysik
- E. Rolfs und W. Rodney, Cauldrons in the Cosmos

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	irregular
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. U. Oberlack
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 816	**Module Topical Courses: "Advanced Accelerator Physics"**					**08.128.816**
Compulsory or elective module	**WP**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Advanced Accelerator Physics" (WP)		2	P		138 h	6 LP
Lecture (WP)	V			3 SWS		
Excercises (WP)	Ü			1 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	Written exam (90-180 Min.) or oral examination (30 Min.)					

Qualification and program goals / Competences

The first objective of the course is to understand spin-polarized ensembles. Later-on, we will discuss their behavior under the conditions of relativistic motion in macroscopic external fields. This regime is governed by the Thomas-BMT equation. The spin dynamics in spin rotators, recirculating linear accelerators, but also in particular for synchrotrons and storage rings will be discussed. The second part is devoted to the realization of spin-sensitive experiments at accelerators which are of course based on the interaction of spins with microscopic fields. Information on these interactions may be obtained by measuring spin sensitive observables, e.g. the analysing power of the process. The presentation of experimental techniques such as polarized sources and polarimeters concludes the course. The course provides the background to successfully complete a master's thesis in the groups at MAMI that deal with experiments based on spin-polarized beams.

Course content

The course will provide knowledge and competence with respect to the following subjects: Spin polarized ensembles, density matrix, Dirac' equation, spin precession in the lab frame (Thomas BMT equation), single pass spin rotators, sibirian snakes, intrinsic and imperfection resonances in storage rings, Sokolov-Ternov effect, spinstable solutions, depolarization by synchrotron radiation, spin equilibrium, spin polarized sources, spin sensitive observables (analyzing powers), polarimetry parity violating observable, Parity violation experiments at accelerators, double polarization experiments with polarized targets at collider facilities.

Literature

- D. Barber: Introduction to Spin polarisation in accelerators and storage rings
- B.W. Montague Physics Reports 113 (1984) 1-96
- A. Lehrach: Strahl und Spin-Dynamik von Hadronenstrahlen in Mittelenergiespeicherringen. Schriften des Forschungszentrums Jülich, Reihe Schlüsseltechnologien, Jülich 2008 ISBN 978-3-89336-548-7

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	6/120
Module frequency	Every summer semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. K. Aulenbacher
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

3.5 Focus Courses

The list of Focus courses changes from semester to semester and is only available in Jogustine. For the general description of the module see below:

Modul 650	**Module "Focus Courses"**				**M.08.128.650**
Compulsory or elective module	**W**				
Credit points and workload	**3-9 LP = 90-270 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Topical Course" Lecture Excercises (WP)	 V Ü	1/2	W	 1.5 SWS 0.5 SWS	69 h	3 LP
Advanced Seminar	OS	1/2	W	2 SWS	69 h	3 LP
Industrial Internship	P	1/2	W	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence	OS, P					
Active participation	according to §5 subsection 3					
Course achievements	successful completion of exercises or projects					
Module examination	This module will not be graded					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English or German
Weighting of the achievement in the overall grade	3-9/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Ostrick
Applicable to the following programs	M.Sc. Physics
Miscellaneous	

3.6 Research Phase

Modul 660	**Specialization**				**M.08.128.660**
Compulsory or elective module	**P**				
Credit points and workload	**15 LP = 450 h**				
Duration according to the study plan	**1**				
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Specialization (P)	F	3	P	60 h	390 h	15 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Working on the research project with at least one weekly supervising discussion.					
Course achievements						
Module examination	A concluding presentation to the working group. There is no grade for this module.					
Qualification and program goals / Competences						
Within a working group the course intends to provide the student with • the special knowledge necessary to successfully complete a master's thesis and the • necessary methods to successfully complete a master's thesis and to work independently on a specific scientific topic.						
Course content						
A preliminary topic of the master's thesis from the research project of an experimental or theoretical working group will be specified which the student will then begin to work on.						

Entry requirements	All teaching units of the master's courses from the 1st and 2nd semester, with the possible exception of the Topical Course II, the Advanced Course and Seminar II.
Recommended prerequisites	All teaching units of the master's courses from the 1st and 2nd semester, with the possible exception of the Topical Course II, the Advanced Course and Seminar II.
Language	Course language German/English Examination language German/English
Weighting of the achievement in the overall grade	0 (The module does not enter in the overall grade)
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Ostrick
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 670	**Methodological Knowledge**					**M.08.128.670**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Methodological Knowledge (P)	F	3	P	60 h	390 h	15 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Learning the methods in addition to at least one weekly supervising discussion					
Course achievements						
Module examination	Based on a concluding presentation to the working group or creating a portfolio					

Qualification and program goals / Competences

Within a working group the lecture intends to provide the student with

- the special knowledge necessary to successfully complete a master's thesis and the
- necessary methods to successfully complete a master's thesis and to work independently on a specific scientific topic.

Course content

For the topic of the master's thesis from the research project of an experimental or theoretical working group, the student will become familiar with the methods necessary to complete the master's thesis.

Entry requirements	Module "Specialization"
Recommended prerequisites	Module "Specialization"
Language	Course language German/English Examination language German/English
Weighting of the achievement in the overall grade	15/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Ostrick
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

Modul 969	**Master Thesis**	**A.08.128.969**
Compulsory or elective module	**P**	
Credit points and workload	**30 LP = 900 h**	
Duration according to the study plan	**1**	

Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Master thesis (P)		4	P	110 h	760 h	29 LP
Final Colloquium (P)		4	P	2 h	28 h	1 LP

To complete the module, the following achievements must be made:	
Presence	
Active participation	Developing the new results at the frontiers of knowledge with at least one weekly supervising discussion
Course achievements	
Module examination	Written master thesis, Final colloquium in front of the working group or a wider audience (siehe §17 PO)

Qualification and program goals / Competences

Students are able to work scientifically on a topic in their chosen field of specialization. They are able to introduce this topic in the form of a scientific paper (Master's thesis), describe and document their results and interpret and discuss them in the light of the relevant literature. They are also able to present and defend their Master's thesis in the form of a scientific presentation and answer questions on the topic and peripheral areas.

Course content

For the topic of the master thesis from the research project of an experimental or theoretical working group, the student will develop new results at the frontiers of knowledge.

Entry requirements	Module "Specialization" and "Methodological Knowledge"
Recommended prerequisites	Module "Specialization" and "Methodological Knowledge"
Language	Course language German/English Examination language German/English
Weighting of the achievement in the overall grade	30/120 (siehe §16 der PO)
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. M. Ostrick
Applicable to the following programs	M.Sc. Physics
Miscellaneous	Course language: English

3.7 Subsidiary Subjects

Currently only the lectures from the Economics subject are always in English. For the other subsidiary subjects it is up to the lecturer to decide about the course language.

3.7.1 Chemistry

Modul 1005	**Nuclear Chemistry**					**M.09.032.1005**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture "Einführung in die Kernchemie" (WP)	V	1	P	2 SWS	39 h	2 LP
Excercises "Einführung in die Kernchemie" (WP)	Ü	1	P	1 SWS	49.5 h	2 LP
Kernchemisches Praktikum I (WP)	Pr	1	P	5 SWS	97.5 h	5 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements						
Module examination	Oral examination (30-45 Min.)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. F. Rösch
Applicable to the following programs	MSc Physik
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Chemistry programs.

Modul 1006	**Nuclear Chemistry (with one additional advanced course)**					**M.09.032.1006**
Compulsory or elective module	**P**					
Credit points and workload	**12 LP = 270 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture "Einführung in die Kernchemie" (WP)	V	1	P	2 SWS	39 h	2 LP

Modul 1006	**Nuclear Chemistry (with one additional advanced course)**					**M.09.032.1006**
Excercises “Einführung in die Kernchemie” (WP)	Ü	1	P	1 SWS	49.5 h	2 LP
Kernchemisches Praktikum I (WP)	Pr	1	P	5 SWS	97.5 h	5 LP
Spezialvorlesung I (WP)		1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements						
Module examination	Oral examination (30-45 Min.)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	12/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. F. Rösch
Applicable to the following programs	
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Chemistry programs.

Modul 1007	**Nuclear Chemistry (with two additional advanced courses)**					**M.09.032.1007**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 270 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture “Einführung in die Kernchemie” (WP)	V	1	P	2 SWS	39 h	2 LP
Excercises “Einführung in die Kernchemie” (WP)	Ü	1	P	1 SWS	49.5 h	2 LP
Kernchemisches Praktikum I (WP)	Pr	1	P	5 SWS	97.5 h	5 LP
Spezialvorlesung I (WP)		1	P	2 SWS	69 h	3 LP
Spezialvorlesung II (WP)		1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements						
Module examination	Oral examination (30-45 Min.)					
Qualification and program goals / Competences						

Modul 1007	**Nuclear Chemistry (with two additional advanced courses)**	**M.09.032.1007**
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. F. Rösch
Applicable to the following programs	
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Chemistry programs.

Modul 1010	**Introduction to Theoretical Chemistry**					**M.09.032.1010**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture/Excercises “Einführung in die Theoretische Chemie” (WP)	V	1	P	5 SWS	127 h	6 LP
Lab course “Computerchemie” (WP)	Pr	1	P	5 SWS	37 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements						
Module examination	Written exam (120 min) or oral examination (30 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Jürgen Gauß
Applicable to the following programs	
Miscellaneous	Course language: German Further details can be found in the german version of the module handbook

Modul 1011	**Theoretical Chemistry**					**M.09.032.1011**
Compulsory or elective module	**P**					
Credit points and workload	**12 LP = 360 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture/Excercises "Theoretische Chemie 1" (WP)	V	1	P	3 SWS	88 h	4 LP
Lab course "Theoretische Chemie 1" (WP)	Pr	1	P	5 SWS	7 h	2 LP
Lecture/Excercises "Theoretische Chemie 2" (WP)	V	1	P	3 SWS	88 h	4 LP
Lab course "Computerchemie" (WP)	Pr	1	P	5 SWS	7 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements	Kolloquium zum Praktikum Computerchemie					
Module examination	Written exam (120 min) or oral examination (30 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	12/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Jürgen Gauß
Applicable to the following programs	MSc Physik
Miscellaneous	Course language: German Further details can be found in the german version of the module handbook

3.7.2 Computer Science

Remarks:

The introductory courses „Einführung in die Programmierung“, „Einführung in die Softwareentwicklung“, as well as „Technische Informatik“ cannot be chosen as part of these modules.

Courses belonging to the theoretical foundation („Theoretische Grundlagen der Informatik I + II“, „Datenstrukturen u. effiziente Algorithmen“) as well as the ones belonging to the focus subjects can be chosen.

The following courses are regularly offered: Computergrafik (Computergrafik Teil I + II, Echtzeitbildverarbeitung, 3D Computer Vision) Informationssysteme (Datenbanken Teil I + II) Datenanalyse (Datenwarehouse + Data-Mining) Modellbildung + Simulation Clientseitige Webanwendungen + Serverseitige Webanwendungen Datenstrukturen u. effiziente Algorithmen Betriebssysteme + verteilte Systeme Kommunikationsnetze Software-Technik.

Modul xx1	**Computer Science I**					**M.08.079.xx1**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Course A (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course A (WP)	V	1	P	1 SWS	79.5 h	3 LP
Lab course A (WP)	V	1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements	succesfull completion of the lab course					
Module examination	Written exam (120 min) or oral examination (30 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	
Applicable to the following programs	
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Computer Science programs.

Modul xx2	**Computer Science II**	**M.08.079.xx2**
Compulsory or elective module	**P**	
Credit points and workload	**12 LP = 360 h**	
Duration according to the study plan	**1**	

Modul xx2	**Computer Science II**					**M.08.079.xx2**
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Course A (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course A (WP)	V	1	P	1 SWS	79.5 h	3 LP
Course B (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course B (WP)	V	1	P	1 SWS	79.5 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements	Written exam (120 min) or oral examination (30 min) for each of the two courses					
Module examination	Average of the two course achievements					
Qualification and program goals / Competences						
Course content						
Entry requirements						
Recommended prerequisites						
Language	Course language German Examination language German or English					
Weighting of the achievement in the overall grade	12/120					
Module frequency						
Reasons for compulsory attendance						
Persons responsible for this module						
Applicable to the following programs						
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Computer Science programs.					

Modul xx3	**Computer Science III**					**M.08.079.xx3**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Course A (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course A (WP)	V	1	P	1 SWS	79.5 h	3 LP
Course B (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course B (WP)	V	1	P	1 SWS	79.5 h	3 LP
Lab course A or B (WP)	V	1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	successful completion of the exercises					
Course achievements	Written exam (120 min) or oral examination (30 min) for each of the two courses Succesfull completion of the lab course					
Module examination	Average of the course achievements					

Modul xx3	**Computer Science III**	**M.08.079.xx3**
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	
Applicable to the following programs	
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Computer Science programs.

Modul xx4	**Computer Science IV**					**M.08.079.xx4**
Compulsory or elective module	**P**					
Credit points and workload	**16 LP = 480 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Course A (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course A (WP)	V	1	P	1 SWS	79.5 h	3 LP
Course B (WP)	V	1	P	2 SWS	69 h	3 LP
Excercises to Course B (WP)	V	1	P	1 SWS	79.5 h	3 LP
Lab course A or B (WP)	V	1	P	2 SWS	99 h	4 LP

To complete the module, the following achievements must be made:	
Presence	
Active participation	successful completion of the exercises
Course achievements	Written exam (120 min) or oral examination (30 min) for each of the two courses Seminar presentation
Module examination	Average of the course achievements
Qualification and program goals / Competences	
Course content	

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	
Reasons for compulsory attendance	
Persons responsible for this module	

Modul xx4	**Computer Science IV**	**M.08.079.xx4**
Applicable to the following programs		
Miscellaneous	Course language: German Further details can be found in the module handbooks of the Computer Science programs.	

3.7.3 Economics

Within the subsidiary subject Economics one out of the following three branches can be selected: „International Economics & Public Policy“, „Finance & Accounting“ and „Marketing, Management & Operations“. In each branch two modules must be succesfully completed.

- Branch 1: „International Economics & Public Policy“
  - International Trade
  - Mikroökonomie II
  - Öffentliche Finanzen
  - Wirtschaftspolitik
  - Intertemporale Optimierung
  - Mikroökonometrie
  - Exchange Rates
  - Makroökonomie II
  - Zeitreihenanalyse
- Branch 2: „Finance & Accounting“
  - Rechnungslegung
  - Steuern
  - Finanzen
  - Controlling
  - Banken
  - Zeitreihenanalyse
- Branch 3: „Marketing, Management & Operations“
  - Organisation
  - Wirtschaftsinformatik
  - Marketing
  - Logistikmanagement

Modul 4140	**International Trade**					**M.03.184.4140**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: International Trade: Theory and Policy	V	1	P	2 SWS	99 h	4 LP
b) Exercises: International Trade: Theory and Policy	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Philipp Harms
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: English Further details can be found in the german version of the module handbook

Modul 4105	**Mikroökonomie II**					**M.03.184.4105**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Mikroökonomie II	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Mikroökonomie II	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Modul 4105	**Mikroökonomie II**	**M.03.184.4105**
Entry requirements		
Recommended prerequisites		
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Winter term	
Reasons for compulsory attendance		
Persons responsible for this module	JProf. Dr. Wondratschek	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 4115	**Öffentliche Finanzen**					**M.03.184.4115**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Öffentliche FInanzen	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Öffentliche FInanzen	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Daniel Schunk
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4120	**Wirtschaftspolitik**					**M.03.184.4120**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Wirtschaftspolitik	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Wirtschaftspolitik	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	

Modul 4120	**Wirtschaftspolitik**	**M.03.184.4120**
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Winter term	
Reasons for compulsory attendance		
Persons responsible for this module	Jun.-Prof. Dr. Iryna Stewen	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 4145	**Intertemporale Optimierung**					**M.03.184.4145**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Intertemporale Optimierung	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Intertemporale Optimierung	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Klaus Wälde
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4405	**Micro Econometrics**					**M.03.184.4405**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Micro Econometrics	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Micro Econometrics	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Modul 4405	**Micro Econometrics**	**M.03.184.4405**
Entry requirements		
Recommended prerequisites		
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Winter term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Reyn van Ewijk	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: English Further details can be found in the german version of the module handbook	

Modul 4125	**Exchange Rates and International Capital Markets**					**M.03.184.4125**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Exchange Rates and International Capital Markets	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Exchange Rates and International Capital Markets	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						
Entry requirements						
Recommended prerequisites						
Language	Course language English Examination language English					
Weighting of the achievement in the overall grade	6/120					
Module frequency	Summer term					
Reasons for compulsory attendance						
Persons responsible for this module	Prof. Dr. Philipp Harms					
Applicable to the following programs	M.Sc. Physik					
Miscellaneous	Language: English Further details can be found in the german version of the module handbook					

Modul 4110	**Makroökonomie II**					**M.03.184.4110**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Makroökonomie II	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Makroökonomie II	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						

Modul 4110	Makroökonomie II	M.03.184.4110
Course content		
Entry requirements		
Recommended prerequisites		
Language		Course language English Examination language English
Weighting of the achievement in the overall grade		6/120
Module frequency		Summer term
Reasons for compulsory attendance		
Persons responsible for this module		Prof. Dr. Klaus Wälde
Applicable to the following programs		M.Sc. Physik
Miscellaneous		Language: English Further details can be found in the german version of the module handbook

Modul 4410	**Zeitreihenanalyse**					**M.03.184.4410**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Zeitreihenanalyse	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Zeitreihenanalyse	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Summer term
Reasons for compulsory attendance	
Persons responsible for this module	N.N.
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4205	**Rechnungslegung nach HGB**					**M.03.184.4205**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Rechnungslegung nach HGB	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Rechnungslegung nach HGB	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Modul 4205	**Rechnungslegung nach HGB**	**M.03.184.4205**
Entry requirements		
Recommended prerequisites		
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Winter term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Stefan Rammert	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 4210	**Steuern**					**M.03.184.4210**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Steuern	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Steuern	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Roland Euler
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4220	**Finanzierung**					**M.03.184.4220**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Finanzierung	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Finanzierung	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	

Modul 4220	**Finanzierung**	**M.03.184.4220**
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Winter term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Siegfried Trautmann	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 4215	**Controlling**					**M.03.184.4215**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Controlling	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Controlling	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Summer term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Louis Velthuis
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4225	**Banken**					**M.03.184.4225**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Banken	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Banken	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	

Modul 4225	**Banken**	**M.03.184.4225**
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Summer term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Dietmar Leisen	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 4310	**Banken**					**M.03.184.4310**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Organisation	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Organisation	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Winter term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Erk Piening
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4320	**Wirtschaftsinformatik**					**M.03.184.4320**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Wirtschaftsinformatik	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Wirtschaftsinformatik	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	

Modul 4320	**Wirtschaftsinformatik**	**M.03.184.4320**
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Winter term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Stefan Irnich	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 4305	**Marketing**					**M.03.184.4305**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Marketing	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Marketing	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language English Examination language English
Weighting of the achievement in the overall grade	6/120
Module frequency	Summer term
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Oliver Heil
Applicable to the following programs	M.Sc. Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 4315	**Logistikmanagement**					**M.03.184.4315**
Compulsory or elective module	**P**					
Credit points and workload	**6 LP = 180 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Lecture: Logistikmanagement	V	1	P	2 SWS	99 h	4 LP
b) Exercises: Logistikmanagement	Ü	1	P	1 SWS	49,5 h	2 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	

Modul 4315	**Logistikmanagement**	**M.03.184.4315**
Language	Course language English Examination language English	
Weighting of the achievement in the overall grade	6/120	
Module frequency	Summer term	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Stefan Irnich	
Applicable to the following programs	M.Sc. Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

3.7.4 History of Natural Sciences

Modul 060	**History of Natural Science I**					**M.08.275.060**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Vorlesung: Geschichte der Naturwissenschaft I (P)	V	1	P	2 SWS	69 h	3 LP
b) Seminar: Einführung in das wissenschaftshistorische Arbeiten (P)	S	1	P	2 SWS	69 h	3 LP
c) Vorlesung: Geschichte der Naturwissenschaft II (P)	V	1	P	2 SWS	69 h	3 LP
d) Lektürekurs (P)		1	P	2 SWS	69 h	3 LP
e) Übungen (P)	Ü	1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Participation in all seminars					
Course achievements	d) Presentation e) Essays and/or Exercises					
Module examination	Oral examination (20-30 Min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/180 (BSc) or 15/120 (MSc)
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Sauer
Applicable to the following programs	BSc. Physik, MSc Physik
Miscellaneous	Course language: German (maybe English) Further details can be found in the german version of the module handbook

Modul 070	**History of Natural Science II**					**M.08.275.070**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Vorlesung: Geschichte der Naturwissenschaft I (P)	S	1	P	2 SWS	129 h	5 LP
b) Lektürekurs (P)		1	P	2 SWS	99 h	4 LP

Modul 070	**History of Natural Science II**	**M.08.275.070**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Participation in all seminars	
Course achievements	a) Presentation and written term paper b) Presentation and report	
Module examination	Oral examination (20-30 Min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/180 (BSc) or 9/120 (MSc)
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Sauer
Applicable to the following programs	BSc. Physik, MSc Physik
Miscellaneous	Course language: German (maybe English) Further details can be found in the german version of the module handbook

3.7.5 Mathematics

Modul 1300	**Functional Analysis**					**M.08.105.1300**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Funktional-analysis I"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1310	**Functional Analysis (with Functional Analysis II)**					**M.08.105.1310**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Functional Analysis I"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Funktionalanalysis II"	V	1	P	4 SWS	138 h	6 LP

Modul 1310	**Functional Analysis (with Functional Analysis II)**	**M.08.105.1310**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Successful completion of the exercises and oral presentation of own solutions.	
Course achievements		
Module examination	Oral examination (20-30 min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1320	**Partial differential equations**					**M.08.105.1320**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Partial differential equations I"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1330	**Partial differential equations (with partial differential equations II)**					**M.08.105.1330**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Partial differential equations I"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Partial differential equations II"	V	1	P	4 SWS	138 h	6 LP

Modul 1330	**Partial differential equations (with partial differential equations II)**	**M.08.105.1330**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Successful completion of the exercises and oral presentation of own solutions.	
Course achievements		
Module examination	Oral examination (20-30 min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1340	**Fundamentals in Stochastics**					**M.08.105.1340**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Introduction to Stochastics"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1350	**Fundamentals in Stochastics**					**M.08.105.1350**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Introduction to Stochastics"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Stochastics I"	V	1	P	4 SWS	138 h	6 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					

Modul 1350	Fundamentals in Stochastics	M.08.105.1350
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1360	**Stochastics I**					**M.08.105.1360**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises “Stochastics I”		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1370	**Stochastics I (with Stochastics II)**					**M.08.105.1370**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises “Stochastics I”		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture “Stochastics II”	V	1	P	4 SWS	138 h	6 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					

Modul 1370	**Stochastics I (with Stochastics II)**	**M.08.105.1370**
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 580	**Stochastics 2**					**M.08.105.580**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture “Stochastics II”	V	1	P	4 SWS	120 h	6 LP
Lecture “Stochastics III”	V	1	P	4 SWS	120 h	6 LP
Oral exam		1	P		90 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Oral examination (20-30 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte. Hauptamtlich
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1380	**Basic Numerics**					**M.08.105.1380**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Basic Numerics"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1390	**Basic Numerics**					**M.08.105.1390**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Grundlagen der Numerik"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Numerik gewöhnlicher Differentialgleichungen"	V	1	P	4 SWS	138 h	6 LP

Modul 1390	**Basic Numerics**	**M.08.105.1390**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Successful completion of the exercises and oral presentation of own solutions.	
Course achievements		
Module examination	Oral examination (20-30 min) or written exam (120 min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1400	**Numerics of differential equations**					**M.08.105.1400**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Numerics of ordinary differential equations"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1410	**Numerics of differential equations**					**M.08.105.1410**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Numerics of ordinary differential equations"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Numerics of partial differential equations"	V	1	P	4 SWS	138 h	6 LP

Modul 1410	**Numerics of differential equations**	**M.08.105.1410**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Successful completion of the exercises and oral presentation of own solutions.	
Course achievements		
Module examination	Oral examination (20-30 min) or written exam (120 min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1420	**Algebra**					**M.08.105.1420**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Computeralgebra"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1430	**Algebra**					**M.08.105.1430**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Computeralgebra"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Körper, Ringe, Moduln"	V	1	P	4 SWS	138 h	6 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					

Modul 1430	**Algebra**	**M.08.105.1430**
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1440	**Topology**					**M.08.105.1440**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Topology"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1450	**Topology (with lecture "Algebraic curves and Riemannian surfaces")**					**M.08.105.1450**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Topology"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Algebraic curves and Riemannian surfaces"	V	1	P	4 SWS	138 h	6 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					

Modul 1450	**Topology (with lecture "Algebraic curves and Riemannian surfaces")**	**M.08.105.1450**
Qualification and program goals / Competences		
Course content		
Entry requirements		
Recommended prerequisites		
Language	Course language German Examination language German or English	
Weighting of the achievement in the overall grade	15/120	
Module frequency	Once per year	
Reasons for compulsory attendance		
Persons responsible for this module	ist der Studiengangsbeauftragte.	
Applicable to the following programs	MSc Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

Modul 1460	**Computer algebra**					**M.08.105.1460**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Computer algebra"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 1470	**Computer algebra (with Number Theory)**					**M.08.105.1470**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Computer algebra"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
Lecture "Number Theory"	V	1	P	4 SWS	138 h	6 LP

Modul 1470	**Computer algebra (with Number Theory)**	**M.08.105.1470**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Successful completion of the exercises and oral presentation of own solutions.	
Course achievements		
Module examination	Oral examination (20-30 min) or written exam (120 min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 10050	**Differential Geometry and Manifolds**					**M.08.105.10050**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Differential Geometry and Manifolds"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 10040	**Function Theory**					**M.08.105.10040**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Function Theory"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					

Modul 10040	**Function Theory**	**M.08.105.10040**
Qualification and program goals / Competences		
Course content		
Entry requirements		
Recommended prerequisites		
Language		Course language German Examination language German or English
Weighting of the achievement in the overall grade		9/120
Module frequency		Once per year
Reasons for compulsory attendance		
Persons responsible for this module		ist der Studiengangsbeauftragte.
Applicable to the following programs		MSc Physik
Miscellaneous		Language: German Further details can be found in the german version of the module handbook

Modul 140	**Number Theory**					**M.08.105.140**
Compulsory or elective module	**P**					
Credit points and workload	**9 LP = 270 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Number Theory"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 650	**Vertiefungsmodul Analysis**					**M.08.105.650**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture "Vertiefungsmodul Analysis I"	V	1	P	4 SWS	138 h	6 LP
Lecture "Vertiefungsmodul Analysis II"	V	1	P	4 SWS	138 h	6 LP
Module examination					90 h	
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Oral examination (20-30 min)					
Qualification and program goals / Competences						

Modul 650	**Vertiefungsmodul Analysis**	**M.08.105.650**
Course content		
Entry requirements		
Recommended prerequisites		
Language		Course language German Examination language German or English
Weighting of the achievement in the overall grade		15/120
Module frequency		Once per year
Reasons for compulsory attendance		
Persons responsible for this module		ist der Studiengangsbeauftragte.
Applicable to the following programs		MSc Physik
Miscellaneous		Language: German Further details can be found in the module handbooks of the Mathematics programs

Modul 560	**Functional Analysis**					**M.08.105.560**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture “Functional Analysis II”	V	1	P	4 SWS	138 h	6 LP
Lecture “Funktionalanalysis III”	V	1	P	4 SWS	138 h	6 LP
Module examination					90 h	
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 625	**Vertiefungsmodul Eichtheorie**					**M.08.105.625**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture “Eichtheorie I”	V	1	P	4 SWS	138 h	6 LP
Lecture “Eichtheorie II”	V	1	P	4 SWS	138 h	6 LP
Module examination					90 h	
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Oral examination (20-30 min)					
Qualification and program goals / Competences						

Modul 625	Vertiefungsmodul Eichtheorie	M.08.105.625
Course content		
Entry requirements		
Recommended prerequisites		
Language		Course language German Examination language German or English
Weighting of the achievement in the overall grade		15/120
Module frequency		Once per year
Reasons for compulsory attendance		
Persons responsible for this module		ist der Studiengangsbeauftragte.
Applicable to the following programs		MSc Physik
Miscellaneous		Language: German Further details can be found in the module handbooks of the Mathematics programs

Modul 070	**Basic Numerics**					**M.08.105.070**
Compulsory or elective module	**P**					
Credit points and workload	**12 LP = 360 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture with excercises "Basic Numerics"		1	P		207 h	9 LP
Lecture (WP)	V			4 SWS		
Excercises (WP)	Ü			2 SWS		
	Pr	1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation	Successful completion of the exercises and oral presentation of own solutions.					
Course achievements						
Module examination	Oral examination (20-30 min) or written exam (120 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	9/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 540	**Complex Differential Geometry**					**M.08.105.540**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture "Complex Differential Geometry I"	V	1	P	4 SWS	138 h	6 LP
Lecture "Complex Differential Geometry II"	V	1	P	4 SWS	138 h	6 LP
Module examination					90 h	

Modul 540	**Complex Differential Geometry**	**M.08.105.540**
To complete the module, the following achievements must be made:		
Presence		
Active participation	Successful completion of the exercises and oral presentation of own solutions.	
Course achievements		
Module examination	Oral examination (20-30 min)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	
Persons responsible for this module	ist der Studiengangsbeauftragte.
Applicable to the following programs	MSc Physik
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 500	**Algebraic Geometry**					**M.08.105.500**
Compulsory or elective module	**P**					
Credit points and workload	**15 LP = 450 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture “Algebraic Geometry I”	V	1	P	4 SWS	120 h	6 LP
Lecture “Algebraic Geometry II”	V	1	P	4 SWS	120 h	6 LP
Oral exam		1	P		90 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Oral examination (20-30 min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	15/120
Module frequency	Once per year
Reasons for compulsory attendance	

Modul 500	**Algebraic Geometry**	**M.08.105.500**
Persons responsible for this module	ist der Studiengangsbeauftragte. Hauptamtlich	
Applicable to the following programs	MSc Physik	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook	

3.7.6 Meteorology

You can find the description of the modules in the corresponding module handbook of the BSc and MSc Meteorology which you can find at this URL:
https://www.studium.fb08.uni-mainz.de/downloadcenter-meteorologie/

3.7.7 Philosophy

Modul 061	**Basismodul (historisch) - Philosophie der Neuzeit**					**M.05.127.061**
Compulsory or elective module	**P**					
Credit points and workload	**5 LP = 150 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Oberseminar: Philosophie der Neuzeit	S	1	P	2 SWS	99 h	4 LP
Modul examination		1	P		30 h	1 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Seminar paper (8-10 pages) or Presentation (+ written report of 5 pages) or written exam (90 Min.) or oral exam (20 Min.) in a)					
Qualification and program goals / Competences						
Course content						
Entry requirements						
Recommended prerequisites						
Language	Course language German Examination language German or English					
Weighting of the achievement in the overall grade	5/120					
Module frequency	Every semester					
Reasons for compulsory attendance						
Persons responsible for this module	Univ.-Prof. Dr. Heiner F. Klemme Hauptamtliche					
Applicable to the following programs						
Miscellaneous	Language: German Further details can be found in the german version of the module handbook					

Modul 063	**Aufbaumodul (historisch) - Philosophie der Neuzeit**					**M.05.127.063**
Compulsory or elective module	**P**					
Credit points and workload	**5 LP = 150 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Oberseminar: Philosophie der Neuzeit	S	2	P	2 SWS	99 h	4 LP
Modul examination		2	P		30 h	1 LP

Modul 063	**Aufbaumodul (historisch) - Philosophie der Neuzeit**	**M.05.127.063**
To complete the module, the following achievements must be made:		
Presence		
Active participation		
Course achievements		
Module examination	Seminar paper (8-10 pages) or Presentation (+ written report of 5 pages) or written exam (90 Min.) or oral exam (20 Min.) in a)	
Qualification and program goals / Competences		
Course content		

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	5/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Univ.-Prof. Dr. Heiner F. Klemme Hauptamtliche
Applicable to the following programs	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

Modul 065	**Vertiefungsmodul (historisch) - Philosophie der Neuzeit**					**M.05.127.065**
Compulsory or elective module	**P**					
Credit points and workload	**5 LP = 150 h**					
Duration according to the study plan	**1**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
a) Oberseminar: Philosophie der Neuzeit	S	3	P	2 SWS	99 h	4 LP
Modul examination		3	P		30 h	1 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Seminar paper (8-10 pages) or Presentation (+ written report of 5 pages) or written exam (90 Min.) or oral exam (20 Min.) in a)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	5/120
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Univ.-Prof. Dr. Heiner F. Klemme Hauptamtliche
Applicable to the following programs	
Miscellaneous	Language: German Further details can be found in the german version of the module handbook

3.8 interdisciplinary Courses

Modul 130	**History of Natural Science I**					**08.275.130**
Compulsory or elective module	**W**					
Credit points and workload	**3 LP = 90 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture: Geschichte der Naturwissenschaft I	V	1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Oral examination (20-30 Min)					
Qualification and program goals / Competences						
Course content						

Entry requirements	
Recommended prerequisites	
Language	Course language German Examination language German or English
Weighting of the achievement in the overall grade	3/180 (BSc) or 3/120 (MSc)
Module frequency	Every semester
Reasons for compulsory attendance	
Persons responsible for this module	Prof. Dr. Sauer
Applicable to the following programs	BSc. Physik, MSc Physik
Miscellaneous	Course language: German (maybe English) Further details can be found in the german version of the module handbook

Modul 140	**History of Natural Science II**					**08.275.140**
Compulsory or elective module	**W**					
Credit points and workload	**3 LP = 90 h**					
Duration according to the study plan	**2**					
Courses and teaching methods	**Type**	**Designated term**	**Degree of obligation**	**Contact time**	**Self study**	**Credit points**
Lecture: Geschichte der Naturwissenschaft II	V	1	P	2 SWS	69 h	3 LP
To complete the module, the following achievements must be made:						
Presence						
Active participation						
Course achievements						
Module examination	Oral examination (20-30 Min)					
Qualification and program goals / Competences						
Course content						

Modul 140	**History of Natural Science II**	**08.275.140**
Entry requirements		
Recommended prerequisites		
Language	Course language German Examination language German or English	
Weighting of the achievement in the overall grade	3/180 (BSc) or 3/120 (MSc)	
Module frequency	Every semester	
Reasons for compulsory attendance		
Persons responsible for this module	Prof. Dr. Sauer	
Applicable to the following programs	BSc. Physik, MSc Physik	
Miscellaneous	Course language: German (maybe English) Further details can be found in the german version of the module handbook	