

# Module Catalogue for the Subject

## Mathematical Physics

as a Master's with 1 major with the degree "Master of Science" (120 ECTS credits)

Examination regulations version: 2012 Responsible: Institute of Mathematics Responsible: Faculty of Physics and Astronomy

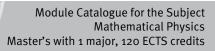


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## The subject is divided into

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#### **Content and Objectives of the Programme**

The Master programme Mathematical Physics is offered jointly by the Department of Mathematics and Computer Science and the Department of Physics and Astronomy.

The Master programme in Mathematical Physics is intended to provide the students with the following qualifications:

- capacity of abstraction,
- rigour in analytic reasoning,
- excellent capacity to realize the structure of complex interrelations,
- sound qualification in applying methods of Mathematics and Theoretical Physics to specific problems,
- insight into the intrinsic mathematical interdependence of different fields in Mathematics, Physics and Mathematical Physics as well as into interdisciplinary relations,
- specialisation in one field of mathematical physics during a one-year research project (so-called master project); the research project includes acquisition of the necessary specialized state-of-the-art knowledge and practical skills needed for independent research leading to the master thesis,
- high stamina in dealing with difficult problems,
- high capacity in problem solving,
- ability to carry out independent scientific work on a high level in research and implementation of mathematical physics,
- ability to cooperate responsibly within an interdisciplinary team of mathematicians, physicists and natural scientists,
- insight into and overview over current research in at least one field of contemporary mathematical physics,
- qualification for meeting the standards of a Ph.D. programme in Mathematics, Physics or Mathematical Physics (if applicable).

For the Master thesis the student works independently on a topic in Mathematical Physics and solves a problem within a limited time frame, following scientific criteria and applying established methods or modifying them if necessary.

The Masters exam ascertains that the candidate has a good overview in the field of Mathematical Physics and possesses the ability to use the corresponding scientific methods independently. The degree Master of Science in Mathematical Physics constitutes a further professional and scientific qualification.



#### **Abbreviations used**

Course types:  $\mathbf{E} = \text{field trip}$ ,  $\mathbf{K} = \text{colloquium}$ ,  $\mathbf{O} = \text{conversatorium}$ ,  $\mathbf{P} = \text{placement/lab course}$ ,  $\mathbf{R} = \text{project}$ ,  $\mathbf{S} = \text{seminar}$ ,  $\mathbf{T} = \text{tutorial}$ ,  $\ddot{\mathbf{U}} = \text{exercise}$ ,  $\mathbf{V} = \text{lecture}$ 

Term: **SS** = summer semester, **WS** = winter semester

Methods of grading: **NUM** = numerical grade, **B/NB** = (not) successfully completed

Regulations: **(L)ASPO** = general academic and examination regulations (for teaching-degree programmes), **FSB** = subject-specific provisions, **SFB** = list of modules

Other: A = thesis, LV = course(s), PL = assessment(s), TN = participants, VL = prerequisite(s)

#### **Conventions**

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

#### **Notes**

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

#### In accordance with

the general regulations governing the degree subject described in this module catalogue:

#### ASP02009

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

#### 12-Jul-2012 (2012-115)

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.

## **Compulsory Courses**

(50 ECTS credits)



Module titl	e		Abbreviation		
Analysis ar	nd Geometry of Classic	al Systems	10-M=MP1-122-m01		
Module cod	ordinator		Module offered by		
Dean of Stu	ıdies Mathematik (Ma	thematics)	Institute of Mathematics		
ECTS Me	thod of grading	Only after succ. co	npl. of module(s)		
10 nui	merical grade				
Duration Module level		Other prerequisites	Other prerequisites		
1 semester	graduate	Other prerequisites  Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			

Modern analytic methods (such as partial differential equations) and geometric methods (such as differential geometry) for the description of classical physics. Examples include movements of deformable bodies as reaction to outer load (deformation of elastic bodies, flow of a fluid, stream of a gas). Additional examples include geometric mechanics and symplectic geometry, classical field theory and classical gauge theory, general relativity theory.

#### **Intended learning outcomes**

The student gains insight into modern methods in mathematics, which are applied in classical physics. He/She masters advanced techniques in this field and is able to apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total)

Language of assessment: German, English

#### Allocation of places

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#### Additional information

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



odule title		Abbreviation		
gebra and Dynamics of Quantum S	Systems		10-M=MP2-122-m01	
odule coordinator		Module offered by		
an of Studies Mathematik (Mathe	matics)	Institute of Mathematics		
TS Method of grading	Only after succ. con	npl. of module(s)		
numerical grade				
ration Module level	Other prerequisites			
ntents	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification admission to assessment anew.   Ints  The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered and the course of the semester, the lecturer will put their registration for assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification admission to assessment anew.			
ended learning outcomes	<u> </u>	.,	- , .	
e student gains insight into mode esters advanced techniques in this				
urses (type, number of weekly contact hour	s, language — if other than Ger	rman)		
- Ü (no information on SWS (week	y contact hours) and co	ourse language avai	lable)	
ethod of assessment (type, scope, lang dule is creditable for bonus)	guage — if other than German,	examination offered — if no	ot every semester, information on whether	
the beginning of the course, the leamination (approx. 90 to 120 minunutes), c) oral examination in grounguage of assessment: German, E	utes; usually chosen), b ups of 2 candidates (ap	) oral examination o	of one candidate each (approx. 20	

**Additional information** 

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title					Abbreviation
Profes	sional S	Specialization Math	nematical Physics		11-FS-MP-122-m01
Modul	e coord	linator		Module offered by	1
		f examination comr ematical Physics)	nittee Mathematische	Faculty of Physics	and Astronomy
ECTS	Meth	od of grading	Only after succ. co	mpl. of module(s)	
10	nume	rical grade			
Duration	on	Module level	Other prerequisites	5	
Conter	nts		at the beginning of sidered a declaration dents have obtained the course of the seasesment into effected to assessment	the course. Registra on of will to seek add d the qualification f emester, the lecture ct. Students who me in the current or in tl date, students will	ents about the respective details ation for the course will be conmission to assessment. If stuor admission to assessment over will put their registration for aset all prerequisites will be admithe subsequent semester. For ashave to obtain the qualification for
				ti I Dh i	ish anasial ralawanaa sa sha alaa
					ith special relevance to the plan- in a seminar presentation.
	·	ning outcomes	, , , , , , , , , , , , , , , , , , , ,	· ·	· · · · · · · · · · · · · · · · · · ·
The stu	udents to the i	have advanced kno ntended topic of the		ow the current state	tical Physics with a special rele- of research in this area and are
Course	es (type, i	number of weekly contact	hours, language — if other than Ge	rman)	
S (no i	nforma	tion on SWS (weekl	y contact hours) and cours	se language availabl	le)
		sessment (type, scope, ble for bonus)	language — if other than German,	examination offered — if r	not every semester, information on whether
		ussion (approx. 30 t assessment: Germa			
Alloca	tion of	places			
Additio	onal inf	ormation			
Referre	ed to in	LPO I (examination reg	ulations for teaching-degree progr	ammes)	



Modul	e title				Abbreviation		
Scienti	Scientific Methods and Project Management Mathematical Physics 11-MP-MP-122-mo1						
Module coordinator				Module offered by	1		
chairperson of examination committee			e	Faculty of Physics	and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)			
10	nume	rical grade					
Duratio	on	Module level	Other prerequisites				
Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective detail at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment ow the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admited to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification admission to assessment anew.  Contents  Introduction to the methods of scientific work, taking into account methods of project planning. Application to			ents about the respective details ation for the course will be conmission to assessment. If stufor admission to assessment over will put their registration for asset all prerequisites will be admithe subsequent semester. For ashave to obtain the qualification for				
		ning outcomes		, , , ,			
thods of ster's t	of a cur hesis. <sup>-</sup>	rent subdiscipline of Ma	athematical Physics wi project plan for the Ma	th special relevanc	including project planning meet to the intended topic of the Maplan the required work. They are		
Course	<b>S</b> (type, r	number of weekly contact hours	, language — if other than Ger	rman)			
S (no i	nforma	tion on SWS (weekly cor	ntact hours) and cours	e language availab	le)		
		sessment (type, scope, languale for bonus)	age — if other than German,	examination offered — if r	not every semester, information on whether		
		ussion (approx. 30 to 45 ssessment: German, En					
Allocat	ion of p	olaces					
Additio	onal inf	ormation					

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title			Abbreviation		
Study Group Mathematical Physics					11-MP-AG-122-m01
Module coordinator N				Module offered by	
chairperson of examination committee Mathematische Physik (Mathematical Physics)		Mathematische	Faculty of Physics and Astronomy		
ECTS Method of grading Only after succ. com		npl. of module(s)			
10	nume	rical grade			
Duratio	on	Module level Other prerequisites			
1 seme	ester graduate				
Contents					

Introduction to current questions of Mathematical Physics as a preparation for a Master's thesis in this research area. Summary of the required fundamental topics in a seminar presentation.

#### **Intended learning outcomes**

The students have advanced knowledge of the subdiscipline of Mathematical Physics and have gained insights into current research topics. They are able to summarise their knowledge in an oral presentation.

Courses (type, number of weekly contact hours, language - if other than German)

#### **Mathematics Courses:**

Arbeitsgemeinschaft Algebra (Study Group Algebra): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, once a year

Arbeitsgemeinschaft Diskrete Mathematik (Study Group Discrete Mathematics): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary

Arbeitsgemeinschaft Dynamische Systeme und Regelung (Study Group Dynamical Systems and Control): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary

Arbeitsgemeinschaft Funktionentheorie (Study Group Complex Analysis): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary

Arbeitsgemeinschaft Geometrie und Topologie (Study Group Geometry and Topology): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary

Arbeitsgemeinschaft Mathematik in den Naturwissenschaften (Study Group Mathematics in the Sciences): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary

Arbeitsgemeinschaft Maß und Integral (Study Group Measure and Integral): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary

Arbeitsgemeinschaft Numerische Mathematik und Angewandte Analysis (Study Group Numerical Mathematics and Applied Analysis): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessarv

Arbeitsgemeinschaft Robotik, Optimierung und Kontrolltheorie (Study Group Robotics, Optimisation and Control Theory): V (2 weekly contact hours) + S (2 weekly contact hours), German or English, available as necessary Arbeitsgemeinschaft Zahlentheorie (Study Group Number Theory): S (2 weekly contact hours), German or English, every two years

#### Physics courses:

Arbeitsgemeinschaft Hopf-Algebren (Study Group Hopf Algebras): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

Arbeitsgemeinschaft Konforme Feldtheorie (Study Group Conformal Field Theory): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

Arbeitsgemeinschaft Moderne Differentialgeometrie (Study Group Modern Differential Geometry): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

Arbeitsgemeinschaft Mathematische Physik (Study Group Mathematical Physics): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

Arbeitsgemeinschaft Operatoralgebren und Darstellungstheorie (Study Group Operator Algebras and Representation Theory): S (no set number of weekly contact hours, mentoring during study group sessions), German or Eng-



Arbeitsgemeinschaft Quantenfeldtheorie (Study Group Quantum Field Theory): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

Arbeitsgemeinschaft Riemannsche Geometrie (Study Group Riemannian Geometry): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

Arbeitsgemeinschaft Symplektische und Poisson-Geometrie (Study Group Symplectic and Poisson Geometry): S (no set number of weekly contact hours, mentoring during study group sessions), German or English Arbeitsgemeinschaft Statistische Mechanik (Study Group Statistical Mechanics): S (no set number of weekly contact hours, mentoring during study group sessions), German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

#### **Mathematics Courses:**

This module will be assessed by one or two of the following methods (to be selected by the lecturer at the beginning of the course):

• Topics covered in one lecture with seminar that is assigned to this module: presentation (60 to 180 minutes), written elaboration (approx. 5 to 30 pages), written examination (approx. 60 to 120 minutes), oral examination of one candidate each (approx. 15 to 20 minutes) or oral examination in groups of 2 candidates (approx. 20 to 30 minutes).

Language of assessment: German or English.

Assessment will be offered in the semester in which the respective course is offered and in the subsequent semester; the courses will be available as necessary or every four semesters.

Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. The lecturer may require that participants have previous knowledge and/or skills in certain areas and/or meet certain prerequisites (e. g. preparation of a written outline of their talk) to qualify for admission to assessment. Students will be informed about the details at the beginning of the course. Registration for the seminar will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment, the lecturer will put their registration for assessment into effect at the end of the course. If the lecturer selects two methods of assessment, the grades achieved in the two assessments will be equally weighted in the calculation of the module grade.

#### Physics courses:

This module will be assessed by a talk on the topics covered in the seminar and a discussion (approx. 30 to 45 minutes total).

Language of assessment German or English

Students must register for assessment online (details to be announced).

To pass this module, students must pass the assessment for the course they attended.

To pass this module, students must pass the assessment for the course they attended.
Allocation of places
Additional information
Referred to in LPO I (examination regulations for teaching-degree programmes)

## **Compulsory Electives**

(40 ECTS credits)



## **Compulsory Electives Mathematics**

(8-32 ECTS credits)



## **Advanced Mathematics**

(ECTS credits)



Module title				Abbreviation		
Applied Analysis 10-M=AAAN-102-mo				10-M=AAAN-102-m01		
Module	coordi	inator		Module offered by		
Dean of	Studie	es Mathematik (Mat	thematics)	Institute of Mathematics		
ECTS	Metho	d of grading	Only after succ. cor	npl. of module(s)		
10	numer	rical grade				
Duration	n	Module level	Other prerequisites			
Duration  1 semester  graduate  Registration for the exercise must be made via SB ning of the course or as announced by the lecturer the specified registration deadlines. Certain prere to qualify for admission to assessment (e. g. succertain percentage of exercises). The lecturer will the respective details at the beginning of the cour exercise will be considered a declaration of will to sessment. If students have obtained the qualificar assessment over the course of the semester, the ligistration for assessment into effect. Students who		exercise must be made via SB@home at the beginar as announced by the lecturer in accordance with ration deadlines. Certain prerequisites must be met sion to assessment (e. g. successful completion of a of exercises). The lecturer will inform students about its at the beginning of the course. Registration for the sidered a declaration of will to seek admission to asts have obtained the qualification for admission to e course of the semester, the lecturer will put their resment into effect. Students who meet all prerequisites assessment in the current or in the subsequent semetate at a later date, students will have to obtain the quant				

In-depth study of functional analysis and operator theory, Sobolev spaces and partial differential equations, theory of Hilbert spaces and Fourier analysis, spectral theory and quantum mechanics, numerical methods (in particular FEM methods), principles of functional analysis, function spaces, embedding theorems, compactness, theory of elliptic, parabolic and hyperbolic partial differential equations with methods from functional analysis.

#### **Intended learning outcomes**

The student is acquainted with the fundamental notions, methods and results of higher analysis. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics and other natural and engineering sciences.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



	title				Abbreviation	
Topics in Algebra 10-M=AALG-102-m01			10-M=AALG-102-m01			
Module o	coordi	nator		Module offered by		
Dean of S	Studie	es Mathematik (Math	ematics)	Institute of Mathem	natics	
CTS I	Metho	d of grading	Only after succ. con	npl. of module(s)		
lo r	numer	ical grade				
Ouration	1	Module level	Other prerequisites	1		
semest	ter	graduate			he lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the n of will to seek admission to aste qualification for admission to ester, the lecturer will put their reddents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the qua-	
Contents	5					

Contemporary topics in algebra, for example coding theory, elliptic curves, algebraic combinatorics or computer algebra.

#### **Intended learning outcomes**

The student is acquainted with fundamental concepts and methods in a contemporary field of algebra, and is able to apply these skills to complex questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### **Allocation of places**

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#### Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module	title				Abbreviation
Differer	ntial G	eometry			10-M=ADGM-102-m01
Module	coord	inator		Module offered by	
Dean of Studies Mathematik (Mathematics)			hematics)	Institute of Mathem	natics
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
10	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
Registration for the exercise must be ning of the course or as announced the specified registration deadlines. to qualify for admission to assessment certain percentage of exercises). The the respective details at the beginning exercise will be considered a declarate sessment. If students have obtained assessment over the course of the significant of the ster. For assessment at a later date,		r as announced by the string deadlines. Cer sion to assessment (of exercises). The least the beginning cosidered a declaration to have obtained the ecourse of the sement into effect. Streassessment in the coassessment in the c	the lecturer in accordance with tain prerequisites must be met (e. g. successful completion of a sturer will inform students about of the course. Registration for the n of will to seek admission to aster, the lecturer will put their resudents who meet all prerequisites arrent or in the subsequent semedents will have to obtain the qua-		
Conten	ts				

Central and advanced results in differential geometry, in particular about differentiable and Riemannian manifolds.

#### **Intended learning outcomes**

The student is acquainted with concepts and methods for differentiable manifolds or Riemannian manifolds, is able to apply these methods and knows about the interaction of local and global methods in differential geometry.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

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#### Additional information

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module coordinator	Module	title				Abbreviation
Dean of Studies Mathematik (Mathematics)  Institute of Mathematics  CTS Method of grading  Only after succ. compl. of module(s)  numerical grade   Duration Module level  Semester graduate Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will have to obtain the qualification for a students will be a students will have	Comple	ex Anal	ysis			10-M=AFTH-102-m01
Puration Module level Other prerequisites  1 semester graduate Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification.	Module	coord	inator		Module offered by	
Duration Module level Prerequisites  1 semester graduate Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification.	Dean of Studies Mathematik (Mathematic			hematics)	Institute of Mathem	natics
Duration  1 semester  graduate  Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification.	ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment at a later date, students will have to obtain the qualification for admission to assessment at a later date, students will have to obtain the qualification for assessment at a later date, students will have to obtain the qualification for admission to assessment at a later date, students will have to obtain the qualification for admission to assessment in the current or in the subsequent semester.	10	nume	rical grade			
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aneution for duminosion to assessment anew.	1 seme	ster	graduate	ning of the course of the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to ster. For assessment	or as announced by the ration deadlines. Cer sion to assessment (of exercises). The least the beginning of sidered a declaration to have obtained the ecourse of the sement into effect. Strassessment in the cut at a later date, study	he lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the n of will to seek admission to aster, the lecturer will put their redents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the qua-

In-depth study of mapping properties of analytic functions and their generalisations with modern analytic and geometric methods. Structural properties of families of holomorphic and meromorphic functions. Special functions (e. g. elliptic functions).

#### **Intended learning outcomes**

The student is acquainted with the fundamental notions, methods and results of higher complex analysis, in particular the (geometric) mapping properties of holomorphic functions. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### **Allocation of places**

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	e title				Abbreviation	
Geome	tric Stı	ructures			10-M=AGMS-102-m01	
Module	e coord	inator		Module offered by	<u></u>	
Dean of Studies Mathematik (Mathema			ematics)	Institute of Mathen	natics	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
10	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
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Conten						
		, generalised polygon s, classification resul		ructures, automorph	nisms, BN pairs in groups, Mouf-	
Intend	ed lear	ning outcomes				

The student is acquainted with the fundamental notions, methods and results concerning a type of geometric structure. He/She is able to establish a connection between these results and broader theories, and learns about the interactions of geometry and other fields of mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, English

#### Allocation of places

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Modul	e title				Abbreviation	
Giovanni-Prodi Lecture (Master)					10-M=AGPC-102-m01	
Modul	e coord	inator		Module offered by		
Dean of Studies Mathematik (Mathematics)			thematics)	Institute of Mathen	natics	
ECTS Method of grading Only		Only after succ. co	mpl. of module(s)			
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites	5		
Duration    Semester   Graduate   Registration for the exercise must be made via SB@home and ning of the course or as announced by the lecturer in according to qualify for admission to assessment (e.g. successful concertain percentage of exercises). The lecturer will inform stuth the respective details at the beginning of the course. Regist exercise will be considered a declaration of will to seek admisses ment. If students have obtained the qualification for accessment over the course of the semester, the lecturer will be admitted to assessment in the current or in the substant of the semester of the semester or in the substant of the semester or in the semester or in the substant of the semester or in the semester or in the substant of the semester or in the substant of the semester or in the substant of the semester or in the substant or in		he lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the n of will to seek admission to aste qualification for admission to ester, the lecturer will put their redents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the qua-				
Conter						
Introdu	iction t	o a specialised topi	c in mathematics by an in	ternational expert.		
Intend	ed lear	ning outcomes				
The ctu	dont:	طلا طلنيي لمملحان ويتممم	a fundamental concents	and mathada of a sar	atomporary rosparch tonic in ma	

The student is acquainted with the fundamental concepts and methods of a contemporary research topic in mathematics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and applications in other subjects.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: English, German if agreed upon with the examiner

#### Allocation of places

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Lie Theory  Module coordinator  Module offered by  Dean of Studies Mathematik (Mathematics)  Institute of Mathematics  ECTS Method of grading  Only after succ. compl. of module(s)  10 numerical grade   Duration Module level  1 semester  The specified registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be method upualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisity will be admitted to assessment in the current or in the subsequent semi ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.  Contents	Module	e title				Abbreviation
Dean of Studies Mathematik (Mathematics)  ECTS Method of grading  Only after succ. compl. of module(s)  numerical grade   Duration Module level  graduate  Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisit will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.	Lie Theory					10-M=ALTH-102-m01
Puration Module level Other prerequisites  1 semester graduate Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisity will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.	Module	Module coordinator			Module offered by	
numerical grade  Duration Module level Other prerequisites  Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisit will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.	Dean of Studies Mathematik (Mathematics)			thematics)	Institute of Mathen	natics
Duration  Module level  Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisity will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.	ECTS Method of grading Only aff		Only after succ. co	mpl. of module(s)		
Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisity will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.	10	nume	rical grade			
ning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to a sessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their gistration for assessment into effect. Students who meet all prerequisit will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.	Duratio	n	Module level	Other prerequisite	S	
Contents	Registration for the exercise must be made via SB@home at the ning of the course or as announced by the lecturer in accordance the specified registration deadlines. Certain prerequisites must be to qualify for admission to assessment (e. g. successful complete certain percentage of exercises). The lecturer will inform students the respective details at the beginning of the course. Registration exercise will be considered a declaration of will to seek admission sessment. If students have obtained the qualification for admission assessment over the course of the semester, the lecturer will put gistration for assessment into effect. Students who meet all prerewill be admitted to assessment in the current or in the subseque ster. For assessment at a later date, students will have to obtain		the lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the n of will to seek admission to asse qualification for admission to ester, the lecturer will put their reducents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the qua-			
	Conten	ts				

examples, applications, e. g. in physics and control theory.

#### **Intended learning outcomes**

The student is acquainted with the fundamental results, theorems and methods in Lie theory. He/She is able to apply these to common problems, and knows about the interactions of group theory, analysis, topology and linear algebra.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title				Abbreviation		
Numeric of la	arge Systems of Equa	ations		10-M=ANGG-102-m01		
Module coor	dinator		Module offered by			
Dean of Studies Mathematik (Mathema		thematics)	Institute of Mather	natics		
ECTS Meth	nod of grading	Only after succ. con	npl. of module(s)			
10 num	erical grade					
Duration	Module level	Other prerequisites	,			
		the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to a	ration deadlines. Ce sion to assessment of exercises). The le ils at the beginning sidered a declaration ts have obtained the course of the semulations of the semulations of the semulations of the course of the semulations of the sem	the lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the on of will to seek admission to asse qualification for admission to ester, the lecturer will put their resudents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the quananew.		
Contents	n of allintic differenti	al aquations, classical ita	ration mathods pro	conditioners multigrid methods		
	rning outcomes	at equations, classical iter	ration methods, pre	conditioners, multigrid methods.		
		e most important method	s for solving large sy	ystems of equations, and knows		
	-	given system of equations.		, 5::5::10 5: 5 4 4 4 4 : 10 : 10 : 10 : 10 : 10 : 10 :		
Courses (type,	number of weekly contact I	hours, language — if other than Ge	rman)			
V + Ü (no info	ormation on SWS (we	ekly contact hours) and co	ourse language avai	lable)		
Method of as		language — if other than German,	examination offered — if n	ot every semester, information on whether		
examination nation in gro		b) oral examination of one orox. 30 minutes)		thods of assessment: a) written pprox. 20 minutes), c) oral exami-		
Allocation of	places					
Additional in	formation					

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Aodule offered by Institute of Mathematics I. of module(s)
nstitute of Mathematics
l. of module(s)
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tercise must be made via SB@home at the beginas announced by the lecturer in accordance with as announced by the lecturer in accordance with ion deadlines. Certain prerequisites must be met on to assessment (e. g. successful completion of a exercises). The lecturer will inform students about at the beginning of the course. Registration for the dered a declaration of will to seek admission to ashave obtained the qualification for admission to course of the semester, the lecturer will put their repent into effect. Students who meet all prerequisites sessment in the current or in the subsequent sement a later date, students will have to obtain the quant to assessment anew.
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Fundamental methods and techniques in continuous optimization, unrestricted optimization, conditions for optimality, restricted optimization, examples and applications in natural and engineering sciences as well as economics.

#### **Intended learning outcomes**

The student knows the fundamental methods of continous optimization, can judge their strengths and weaknesses and can decide which method is the most suitable in applications.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

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#### Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module	e title				Abbreviation	
Introdu	ıction 1	to Control Theory			10-M=ARTH-102-m01	
Module	e coord	linator		Module offered by		
Dean of Studies Mathematik (Mathemat			hematics)	Institute of Mathem	natics	
ECTS Method of grading		Only after succ. con	npl. of module(s)			
10	nume	rical grade				
Duratio	n	Module level	Other prerequisites	1		
puration   Semester   Graduate   Registration for the exercise must be made via SB@home at the ning of the course or as announced by the lecturer in accordant the specified registration deadlines. Certain prerequisites must to qualify for admission to assessment (e. g. successful complete certain percentage of exercises). The lecturer will inform student the respective details at the beginning of the course. Registrati exercise will be considered a declaration of will to seek admissions sessment. If students have obtained the qualification for admission for assessment into effect. Students who meet all provided in the current or in the subsequence of the semester. For assessment at a later date, students will have to obtain liftication for admission to assessment anew.				ne lecturer in accordance with tain prerequisites must be met (e. g. successful completion of a turer will inform students about of the course. Registration for the n of will to seek admission to aster, the lecturer will put their readents who meet all prerequisites arrent or in the subsequent semedents will have to obtain the qua-		
Conten	ts					
		o mathematical syst in optimal control.	ems theory: stability, con	trollability and obser	vability, state feedback and sta-	

#### **Intended learning outcomes**

The student is acquainted with the fundamental notions and methods of control theory. He/She is able to establish a connection between these results and broader theories, and learns about the interactions of geometry and other fields of mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 90 to 120 minutes); if announced by the lecturer, the written examination can be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German or English

#### Allocation of places

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#### Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title Abbreviation					
Stochastical Processes			10-M=ASTP-102-m01		
Module coordinator		Module offered by	J.		
Dean of Studies Mathematik (Mathematics)		Institute of Mathen	matics		
ECTS Method of grading	Only after succ. con	npl. of module(s)			
o numerical grade					
Ouration Module level	Other prerequisites				
semester graduate	ning of the course of the specified registration qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to a	r as announced by the ation deadlines. Cellision to assessment of exercises. The least the beginning of the sement into effect. Streament in the cellist at a later date, studies as a later date, studies as a sment into effect.	ade via SB@home at the begin- the lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the on of will to seek admission to as- e qualification for admission to ester, the lecturer will put their re- udents who meet all prerequisites urrent or in the subsequent seme- dents will have to obtain the qua-		
Contents					
Markov chains, queues, stochastic p	rocesses in C[0,1], Brov	vnian motion, Dons	ker's theorem, projective limits.		
ntended learning outcomes					
he student is acquainted with the fu hem to practical problems.	ındamental notions an	d methods of stocha	astical processes and can apply		
<b>Courses</b> (type, number of weekly contact hours	s, language — if other than Ge	rman)			
/ + Ü (no information on SWS (weekl	y contact hours) and co	ourse language avai	lable)		
<b>Method of assessment</b> (type, scope, lang nodule is creditable for bonus)	uage — if other than German,	examination offered — if no	ot every semester, information on whether		
At the beginning of the course, the le examination (90 to 120 minutes), b) on nation in groups (groups of 2, approximation anguage of assessment: German, En	oral examination of one a. 30 minutes)				
Allocation of places					
-					
Additional information					
-					
Referred to in LPO I (examination regulation	ons for teaching-degree progra	mmes)			



	itle			Abbreviation
Topology	1			10-M=ATOP-102-m01
Module c	oordinator		Module offered by	
Dean of S	Studies Mathematik (Ma	thematics)	Institute of Mathem	atics
ECTS Method of grading Only after		Only after succ. con	npl. of module(s)	
10 n	umerical grade			
Duration	Module level	Other prerequisites	·	
1 semester graduate		ning of the course of the specified registre to qualify for admissing certain percentage of the respective detail	or as announced by the ration deadlines. Cert sion to assessment (of exercises). The lect list at the beginning of sidered a declaration	de via SB@home at the begin- ne lecturer in accordance with tain prerequisites must be met e. g. successful completion of a turer will inform students about f the course. Registration for the n of will to seek admission to as-

Set-theoretic topology, topological invariants (e. g. fundamental group, connection), construction of topological spaces, covering spaces.

#### **Intended learning outcomes**

The student is acquainted with the fundamental results, theorems and methods in topology and is able to apply these to common problems.

 $\textbf{Courses} \ (\textbf{type, number of weekly contact hours, language} - \textbf{if other than German})$ 

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### **Allocation of places**

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#### **Additional information**

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module coording Dean of Studies	ator			10-M=AZTH-102-m01
Dean of Studies				
	Mathamatik (Mathama		Module offered by	
	Mathematik (Mathema	atics) Institute of Mathematics		
ECTS   Method	ECTS Method of grading		npl. of module(s)	
10 numerio	cal grade			
Duration N	Module level	Other prerequisites		
1 semester graduate		ning of the course of the specified registry to qualify for admission certain percentage of the respective detail exercise will be consessment. If student assessment over the gistration for assess will be admitted to a ster. For assessment	r as announced by the ration deadlines. Cer sion to assessment (of exercises). The lect is at the beginning of sidered a declaration its have obtained the ecourse of the sement into effect. Studssessment in the curses of the sement in the s	Ide via SB@home at the begin- ne lecturer in accordance with tain prerequisites must be met (e. g. successful completion of a sturer will inform students about of the course. Registration for the n of will to seek admission to aster, the lecturer will put their resudents who meet all prerequisites arrent or in the subsequent semedents will have to obtain the quanew.

Number-theoretic functions and their associated Dirichlet series resp. Euler products, their analytic theory with applications to prime number distribution and diophantine equations; discussion of the Riemann hypothesis, overview of the development of modern number theory.

#### **Intended learning outcomes**

The student is acquainted with the fundamental methods of analytics number theory, can deal with algebraic structures in number theory and knows methods for the solution of diophantine equations. He/She has insight into modern developments in number theory.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



## **Specialisation Mathematics**

(ECTS credits)



mouule	title			Abbreviation			
Selecte	d Topi	cs in Analysis			10-M=VANA-122-m01		
Module coordinator				Module offered b	y		
Dean of Studies Mathematik (Mathema			nematics)	Institute of Mathe	ematics		
ECTS	Metho	od of grading	Only after succ. co	mpl. of module(s)			
10	nume	rical grade					
Duratio	n	Module level	Other prerequisite	·s			
1 semes		graduate	sessment. The lect at the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment sessment at a late	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective deta at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment of the course of the semester, the lecturer will put their registration for a sessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For a sessment at a later date, students will have to obtain the qualification admission to assessment anew.			
		ussion of a specialise thematical concepts		ng into account rece	nt developments and interrelations		
Intende	ed lear	ning outcomes					
The stu comple		•	vanced results in a selec	ted topic in analysi	s, and is able to apply these to		
_	<b>S</b> (type, r	number of weekly contact ho	ours, language — if other than G	erman)			
Course							

module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### **Allocation of places**

#### **Additional information**

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title				Abbreviation	
Algebraic Topology				10-M=VATP-102-m01	
Module coordinator			Module offered by		
Dean of Studies Mathematik (Mathematics)			Institute of Mathematics		
ECTS I	_		mpl. of module(s)		
10 ľ	numerical grade		-		
Duration	Duration Module level Other prerequi		iites		
1 semest	er graduate	ning of the course of the specified registr to qualify for admis certain percentage the respective detail exercise will be con sessment. If studen assessment over th gistration for assess will be admitted to ster. For assessment	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Contents	5				
Homolog spaces.	gy, homotopy invariance,	exact sequences, cohomo	ology, application to	the topology of Euclidean	
Intended	l learning outcomes				
The student is acquainted with advanced results in algebraic topology.					
Courses	(type, number of weekly contact	hours, language — if other than Ge	rman)		
V + Ü (no information on SWS (weekly contact hours) and course language available)					
	of assessment (type, scope, reditable for bonus)	language — if other than German,	examination offered — if r	not every semester, information on whether	
examina minutes)	tion (approx. 90 to 120 n	ninutes; usually chosen), b groups of 2 candidates (ap	o) oral examination	thods of assessment: a) written of one candidate each (approx. 20 tal)	
	on of places				
Additional information					
Referred	to in LPO I (examination reg	rulations for teaching-degree progra	ammes)		



Module title				Abbreviation	
Discrete Mathematic 10-M=VDIM-102-m01				10-M=VDIM-102-m01	
Module coordinator			Module offered by		
Dean of Studies Mathematik (Mathematics)			Institute of Mathematics		
ECTS M	, , , , , , , , , , , , , , , , , , ,		ompl. of module(s)		
5 nu	ımerical grade				
· i		Other prerequisites	Other prerequisites		
1 semeste	r graduate	ning of the course of the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to ster. For assessment	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Contents					
	methods and results in ory or combinatorics)	a selected field of discret	e mathematics (e. g	. coding theory, cryptography,	
Intended l	earning outcomes				
The stude	nt is acquainted with ac	dvanced results in a select	ed topic in discrete	mathematics.	
Courses (ty	pe, number of weekly contact h	hours, language — if other than Ge	rman)		
V + Ü (no i	nformation on SWS (we	ekly contact hours) and co	ourse language avai	lable)	
	assessment (type, scope, ditable for bonus)	${\tt language-ifotherthanGerman,}$	examination offered — if n	ot every semester, information on whether	
examination in g nation in g Assessme semester,	on (60 to 90 minutes), by groups (groups of 2, app nt offered: Assessment	b) oral examination of one orox. 20 minutes) offered in the semester in and or every four semester	candidate each (ap	thods of assessment: a) written prox. 15 minutes), c) oral examisoffered and in the subsequent	
Allocation	of places				
Additional	information				

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title				Abbreviation	
Dynamical Systems and Control					10-M=VDSR-102-m01
Modul	e coord	inator		Module offered by	
Dean of Studies Mathematik (Mathema		natics)	Institute of Mathematics		
ECTS			Only after succ. compl. of module(s)		
5	nume	rical grade			
Durati	on	Module level	Other prerequisites		
1 semester			Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Conte	nts				
stems;	; select		. networked dynamica		ergodic theory, Hamiltonian syar stability, dynamics with restric-
Intended learning outcomes					
The student masters the mathematical methods in the theory of dynamic systems and control, and is able to analyse their quality.					
Course	es (type, i	number of weekly contact hours,	, language — if other than Ge	rman)	
V + Ü (no information on SWS (weekly contact hours) and course language available)					

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

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#### **Additional information**

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title					Abbreviation	
Groups and their Representations			s		10-M=VGDS-102-m01	
Module coordinator				Module offered by		
Dean of Studies Mathematik (Mathematics		thematics)	Institute of Mathematics			
ECTS Method of grading		Only after succ. o	Only after succ. compl. of module(s)			
10	nume	rical grade				
Duration Module level		Module level	Other prerequisit	Other prerequisites		
1 semester		graduate	ning of the course the specified regi to qualify for adm certain percentag the respective de exercise will be c sessment. If stud assessment over gistration for asse will be admitted t ster. For assessm	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent seme ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Conter						
Finite permutation groups and character theory of finite groups, interrelations and special techniques such as the S-rings of Schur.						
Intend	ed lear	ning outcomes				

The student masters advanced algebraic concepts and methods. He/She gains the ability to work on contemporary research questions in group theory and representation theory and can apply his/her skills to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

#### Allocation of places

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#### Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module	title			Abbreviation		
Geometr	rical N	<b>Nechanics</b>		10-M=VGEM-102-m01		
Module	coord	inator		Module offered by		
Dean of	Studi	es Mathematik (Mat	hematics)	Institute of Mathematics		
ECTS I	Metho	od of grading	Only after succ. con	ıpl. of module(s)		
10	nume	rical grade				
Duration	1	Module level	Other prerequisites	Other prerequisites		
1 semest	ter	graduate	ning of the course of the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to a ster. For assessment	exercise must be made via SB@home at the begin- r as announced by the lecturer in accordance with ration deadlines. Certain prerequisites must be met sion to assessment (e. g. successful completion of a of exercises). The lecturer will inform students about ls at the beginning of the course. Registration for the sidered a declaration of will to seek admission to asts have obtained the qualification for admission to e course of the semester, the lecturer will put their re- sment into effect. Students who meet all prerequisites assessment in the current or in the subsequent seme- t at a later date, students will have to obtain the qua- ion to assessment anew.		

Contents

Introduction to geometric mechanics: basic notions of differential geometry and symplectic geometry, Euler-Lagrange equations, Hamiltonian mechanics on manifolds.

### **Intended learning outcomes**

The student is able to apply fundamental methods and concepts of geometry to problems in mechanics, and knows about the interrelation of these fields.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

# **Allocation of places**

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# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title Abbreviation					
Aspect	ts of Ge	eometry			10-M=VGEO-102-m01
Modul	e coord	linator		Module offered by	L
Dean c	of Studi	es Mathematik (Mather	natics)	Institute of Mathen	natics
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)	
5	nume	erical grade			
Duratio	on	Module level	Other prerequisites		
1 semester graduate		Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			
Conter	nts	,			
		ussion of a special type thematical structures, e			velopments and interrelations letries.
Intend	ed lear	ning outcomes			
	udent is ex prob		nced results in a select	ed field of geometry	and can apply his/her skills to
Course	es (type,	number of weekly contact hours	s, language — if other than Ge	rman)	
V + Ü (	no info	rmation on SWS (weekl	y contact hours) and co	ourse language avail	lable)
Metho	d of ac	SASSMANT (type scene lang	uage — if other than Gorman	ovamination offered if no	ot every semester information on whether

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, English

# **Allocation of places**

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module title Abbreviation					
Giovan	ni-Pro	di Lecture Selected Top		10-M=VGPC-122-m01	
Module	e coord	inator		Module offered by	
Dean o	f Studi	es Mathematik (Mathe	matics)	Institute of Mather	matics
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
10	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
1 semester graduate		sessment. The lecturate the beginning of sidered a declaration dents have obtained the course of the sessment into effect ted to assessment it sessment at a later	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Introdu	ction t	o a specialised topic ir	mathematics by an int	ernational expert.	
Intend	ed lear	ning outcomes			
themat	tics. He		sh a connection betwee		ntemporary research topic in maskills and other branches of ma
Course	<b>S</b> (type, i	number of weekly contact hou	rs, language — if other than Ge	rman)	
V + Ü (ı	no info	rmation on SWS (week	ly contact hours) and co	ourse language avai	lable)
		sessment (type, scope, lang ble for bonus)	guage — if other than German,	examination offered — if n	ot every semester, information on whether
At the l	beginni	ing of the course, the le	ecturer will choose one	of the following me	thods of assessment: a) written

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (approx. 90 to 120 minutes; usually chosen), b) oral examination of one candidate each (approx. 20

minutes), c) oral examination in groups of 2 candidates (approx. 30 minutes total) Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent

semester, course offered on demand or every four semesters. Language of assessment: English, German if agreed upon with the examiner

# Allocation of places

# **Additional information**



Module	e title				Abbreviation
Basics in Mathematics					10-M=VGRM-102-m01
Module	e coord	linator		Module offered by	
Dean o	f Studi	es Mathematik (Mathema	atics)	Institute of Mather	matics
ECTS	Meth	od of grading	Only after succ. con	ıpl. of module(s)	
5	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
Conten	ıts		the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If student assessment over the gistration for assess will be admitted to a	ation deadlines. Ce sion to assessment of exercises). The leads at the beginning of the semant in the certain the	the lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the in of will to seek admission to asse qualification for admission to ester, the lecturer will put their reudents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the quanew.
Discus: and ph			on the foundation of	mathematics, appl	ying methods of set theory, logic
Intende	ed lear	ning outcomes			
The stu	ıdent is	acquainted with the fou	ndational methods ir	n mathematics and l	ogic.
Course	S (type, i	number of weekly contact hours,	language — if other than Ger	man)	
V + Ü (1	no info	rmation on SWS (weekly	contact hours) and co	ourse language avai	lable)
		sessment (type, scope, langua ble for bonus)	age — if other than German, o	examination offered — if n	ot every semester, information on whether
examin nation Langua	nation ( in grou age of a	(60 to 90 minutes), b) ora ups (groups of 2, approx. ussessment: German, Eng	al examination of one 20 minutes)		thods of assessment: a) written prox. 15 minutes), c) oral exami-
Allocat	1011 01	piaces			
 Additio		io umo ati o m			
Additio	nat inf	ormation			

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



					•	
Module	e title				Abbreviation	
Mathe	matical	Continuum Mechanics			10-M=VKOM-122-m01	
Module	e coord	inator		Module offered by		
Dean o	f Studi	es Mathematik (Mathema	atics)	Institute of Mathem	natics	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
Certain prerequisites must be met to qualify for admission to as sessment. The lecturer will inform students about the respective at the beginning of the course. Registration for the course will be sidered a declaration of will to seek admission to assessment. It dents have obtained the qualification for admission to assessment the course of the semester, the lecturer will put their registration sessment into effect. Students who meet all prerequisites will be ted to assessment in the current or in the subsequent semester sessment at a later date, students will have to obtain the qualification to assessment anew.  Contents			nts about the respective details ion for the course will be consission to assessment. If sturadmission to assessment over will put their registration for astall prerequisites will be admite subsequent semester. For as-			
Intend	ed lear	ning outcomes				
1		nasters the mathematical application.	methods in mathem	atical continuum me	chanics and knows about their	
Course	S (type, r	number of weekly contact hours, l	anguage — if other than Gei	rman)		
V + Ü (ı	no info	rmation on SWS (weekly	contact hours) and co	ourse language avail	able)	
		<b>sessment</b> (type, scope, langua ble for bonus)	ge — if other than German,	examination offered — if no	ot every semester, information on whether	
examir nation Assess semes	nation ( in grou sment o ter, cou age of a	60 to 90 minutes), b) ora ps (groups of 2, approx. ffered: Assessment offer arse offered on demand o assessment: German, Eng	I examination of one 20 minutes) ed in the semester in r every four semester	candidate each (app which the course is	hods of assessment: a) written prox. 15 minutes), c) oral examioffered and in the subsequent	

Master's with 1 major Mathematical Physics (2012)

**Additional information** 



Module title Abbreviation						
Mathe	matica	l Imaging			10-M=VMBV-102-m01	
Modul	e coord	linator		Module offered by		
Dean o	f Studi	es Mathematik (Mathem	natics)	Institute of Mathem	natics	
ECTS	Meth	od of grading	Only after succ. con	pl. of module(s)		
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 semester graduate		Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.				
Conter	ts					
camera	a mode	ls and camera calibratio	n, rigid and non-rigid	registration, reconst	elementary projective geometry, cruction of 3D objects from camemethods and tomography.	
Intend	ed lear	ning outcomes				
		nasters the mathematical cation.	ll methods in the theo	ry of image processi	ng and knows about their main	
Course	<b>S</b> (type, i	number of weekly contact hours,	language — if other than Ger	man)		
V + Ü (	no info	rmation on SWS (weekly	contact hours) and co	urse language avail	lable)	

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, English

# **Allocation of places**

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### **Additional information**

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module tit	tle		Abbreviation
Selected 1	Topics in Mathematical	Physics	10-M=VMPH-102-m01
Module co	ordinator		Module offered by
Dean of St	tudies Mathematik (Ma	thematics)	Institute of Mathematics
ECTS M	ethod of grading	Only after succ. cor	ıpl. of module(s)
5 nı	ımerical grade		
Duration	Module level	Other prerequisites	
1 semeste	r graduate	ning of the course of the specified regist to qualify for admis certain percentage the respective deta exercise will be con sessment. If studen assessment over th gistration for assess will be admitted to	exercise must be made via SB@home at the begin- r as announced by the lecturer in accordance with ration deadlines. Certain prerequisites must be met sion to assessment (e. g. successful completion of a of exercises). The lecturer will inform students about ls at the beginning of the course. Registration for the sidered a declaration of will to seek admission to as- ts have obtained the qualification for admission to e course of the semester, the lecturer will put their re- sment into effect. Students who meet all prerequisites assessment in the current or in the subsequent seme- t at a later date, students will have to obtain the qua-

Selected topics in mathematical physics (e. g. differential equations of mathematical physics, probability theory, hydrodynamics, hyperbolic conservation equations, mathematical materials science, quantum mechanics).

## **Intended learning outcomes**

The student is acquainted with advanced results in a field in mathematical physics. He/She knows mathematical methods in mathematical physics and can apply them to solve problems in physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

### Allocation of places

# Additional information



Modul	e title				Abbreviation
Modul	Theory	1			10-M=VMTH-102-m01
Modul	e coord	inator	_	Module offered by	·
Dean	of Studi	es Mathematik (Mat	nematics)	Institute of Mathe	matics
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)	
5	nume	rical grade			
Durati	on	Module level	Other prerequisites	3	
1 semester graduate		ning of the course of the specified regist to qualify for admis certain percentage the respective deta exercise will be con sessment. If studen assessment over th gistration for asses will be admitted to	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qua-		
	in moc				on and representations, simple, rsion theorems, reduction theo-
Intend	ed lear	ning outcomes			
The st	udent m	nasters mathematica	l methods in module the	ory and is able to ar	nalyse their quality.
Course	<b>es</b> (type, r	number of weekly contact h	ours, language — if other than Ge	rman)	
V + Ü (	no info	rmation on SWS (we	ekly contact hours) and c	ourse language ava	ilable)
		<b>sessment</b> (type, scope, l ble for bonus)	anguage — if other than German,	examination offered — if r	not every semester, information on whether
At the	beginn	ing of the course, the	e lecturer will choose one	of the following me	thods of assessment: a) written

examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, English

# Allocation of places

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module title Abbreviation					Abbreviation
Non-Li	near Aı	nalysis			10-M=VNAN-102-m01
Modul	e coord	linator		Module offered by	
Dean o	f Studi	es Mathematik (Mathe	ematics)	Institute of Mathen	natics
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
5	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
1 semester graduate		ning of the course of the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to a	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qua-		
Conter					
Metho	ds in n	onlinear analysis (e. g.	topological methods, n	nonotony and variati	ional methods) with applications.
Intend	ed lear	ning outcomes			
		s acquainted with the cical problems.	concepts of non-linear a	nalysis, can compar	re them and assess their applica-
Course	<b>S</b> (type,	number of weekly contact hou	rs, language — if other than Ge	man)	
V + Ü (	no info	rmation on SWS (week	ly contact hours) and co	ourse language avail	lable)
		<b>sessment</b> (type, scope, lan	guage — if other than German,	examination offered — if no	ot every semester, information on whether

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, English

# **Allocation of places**

### **Additional information**

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module title					Abbreviation	
Numeri	ic of Pa	rtial Differential Eq	uations		10-M=VNPE-102-m01	
Module	e coord	inator		Module offered by		
Dean o	f Studi	es Mathematik (Ma	thematics)	Institute of Mathem	natics	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
10	nume	rical grade				
Duratio	on	Module level	Other prerequisites	Other prerequisites		
1 semester graduate Registration for the ening of the course or the specified registration qualify for admissing certain percentage of the respective details exercise will be consistent sessment. If students assessment over the gistration for assessment.		or as announced by the ration deadlines. Cer sion to assessment (of exercises). The lectils at the beginning of sidered a declaration its have obtained the ecourse of the sement into effect. Students of the sement into effect. Students of the sement into effect.	de via SB@home at the begin- he lecturer in accordance with tain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the n of will to seek admission to as- e qualification for admission to ester, the lecturer will put their re- udents who meet all prerequisites urrent or in the subsequent seme-			

Types of partial differential equations, qualitative properties, finite differences, finite elements, error estimates (numerical methods for elliptic, parabolic and hyperbolic partial differential equations; finite elements method, discontinuous Gelerkin finite elements method, finite differences and finite volume methods).

# **Intended learning outcomes**

The student is acquainted with advanced methods for discretising partial differential equations.

Courses (type, number of weekly contact hours, language - if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

# **Allocation of places**

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# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title				Abbreviation
Optimal Control				10-M=VOST-102-m01
Module coord	inator		Module offered by	
Dean of Studio	es Mathematik (Mathema	atics)	Institute of Mathen	natics
ECTS Metho	od of grading	Only after succ. con	npl. of module(s)	
5 nume	rical grade			
Duration	Module level	Other prerequisites		
1 semester	graduate	ning of the course of the specified registry to qualify for admission certain percentage of the respective detail exercise will be consessment. If student assessment over the gistration for assess will be admitted to a	r as announced by thation deadlines. Cellision to assessment of exercises). The least the beginning of the sement into effect. Streament in the cellist at a later date, studies as a later date, studies as announced the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies as a session of the sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date, studies are sement in the cellist at a later date.	ade via SB@home at the beginhe lecturer in accordance with rtain prerequisites must be met (e. g. successful completion of a cturer will inform students about of the course. Registration for the n of will to seek admission to ase qualification for admission to ester, the lecturer will put their reudents who meet all prerequisites urrent or in the subsequent semedents will have to obtain the quanew.
Rasics in onti	mal control of ordinary a	nd nartial differential	equations theory o	f optimal control, conditions for
	ethods for numerical solu		equations, theory o	r optimat control, conditions for
Intended lear	ning outcomes			
	acquainted with advanc questions in continuous		al control. He gains	the ability to work on contempo-
Courses (type, r	number of weekly contact hours,	language — if other than Ger	man)	
V + Ü (no infor	rmation on SWS (weekly	contact hours) and co	ourse language avai	lable)
Method of ass module is creditab		age — if other than German, o	examination offered — if n	ot every semester, information on whether
examination ( nation in grou Language of a	6o to 90 minutes), b) ora ps (groups of 2, approx. ssessment: German, Eng	al examination of one 20 minutes)		chods of assessment: a) written prox. 15 minutes), c) oral exami-
Allocation of p	olaces			

**Additional information** 



Module	title			Abbreviation		
Quantur	n Cont	trol and Quantum C	omputing	10-M=VQKC-102-m01		
Module	coordi	inator		Module offered by		
Dean of	Studie	es Mathematik (Mat	hematics)	Institute of Mathematics		
ECTS	Metho	d of grading	Only after succ. con	npl. of module(s)		
5	numer	rical grade				
Duration	1	Module level	Other prerequisites	Other prerequisites		
1 semes	ter	graduate	ning of the course of the specified registre to qualify for admission certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to a ster. For assessment	exercise must be made via SB@home at the begin- r as announced by the lecturer in accordance with ration deadlines. Certain prerequisites must be met sion to assessment (e. g. successful completion of a of exercises). The lecturer will inform students about ls at the beginning of the course. Registration for the sidered a declaration of will to seek admission to as- ts have obtained the qualification for admission to e course of the semester, the lecturer will put their re- sment into effect. Students who meet all prerequisites assessment in the current or in the subsequent seme- t at a later date, students will have to obtain the qua- ion to assessment anew.		

Basics in dynamics of quantum-mechanical systems (e. g. density operators, observables, Schrödinger equation, Liouville-von-Neumann equation), bilinear control systems in quantum mechanics (e. g. finite-dimensional spin systems and/or infinite-dimensional Schrödinger equations with external control), applications (e. g. in quantum computing or magnetic resonance spectroscopy).

### **Intended learning outcomes**

The student is acquainted with advanced methods in quantum-mechanical control systems. He gains the ability to work on contemporary research questions in and applications of control systems in quantum mechanics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.

Language of assessment: German, English

## **Allocation of places**

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### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module title				Abbreviation	
Statist	ical An	alysis		10-M=VSTA-102-m01	
Module	e coord	linator		Module offered by	
Dean o	f Studi	es Mathematik (Mat	thematics)	Institute of Mathematics	
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)	
10	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
1 semester graduate R n th to c the semester graduate gra		ning of the course of the specified regist to qualify for admis certain percentage the respective deta exercise will be con sessment. If studer assessment over the gistration for asses will be admitted to ster. For assessment	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisite will be admitted to assessment in the current or in the subsequent sem ster. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Conten	its				
Contingency tables, categorical regression, one-factorial variance analysis, two-factorial variance analysis, discriminant function analysis, cluster analysis, principal component analysis, factor analysis.					

## **Intended learning outcomes**

The student is acquainted with the fundamental methods in statistical analysis and can apply them to practical problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (90 to 120 minutes), b) oral examination of one candidate each (approx. 20 minutes), c) oral examination in groups (groups of 2, approx. 30 minutes)

Language of assessment: German, English

### Allocation of places

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Modul	Module title				Abbreviation	
Netwo	rked Sy	/stems			10-M=VVSY-102-m01	
Modul	e coord	linator		Module offered by	1	
Dean c	of Studi	es Mathematik (Mat	hematics)	Institute of Mathe	matics	
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
5	nume	erical grade				
Durati	on	Module level	Other prerequisites			
1 Seme		graduate	ning of the course of the specified registr to qualify for admiss certain percentage of the respective detail exercise will be consessment. If studen assessment over the gistration for assess will be admitted to ster. For assessment	Registration for the exercise must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Certain prerequisites must be met to qualify for admission to assessment (e. g. successful completion of a certain percentage of exercises). The lecturer will inform students about the respective details at the beginning of the course. Registration for the exercise will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
Conte						
Contemporary topics in networked linear and non-linear dynamical systems (homogenous and non-homogenous systems); analysis of control-theoretical aspects (controllability, accessibility, etc.).						
Intended learning outcomes						
The student is acquainted with advanced methods in the field of networked systems. He gains the ability to work on contemporary research questions in networked systems.						
Courses (type, number of weekly contact hours, language — if other than German)						

**Courses** (type, number of weekly contact hours, language — if other than German)

V + Ü (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

At the beginning of the course, the lecturer will choose one of the following methods of assessment: a) written examination (60 to 90 minutes), b) oral examination of one candidate each (approx. 15 minutes), c) oral examination in groups (groups of 2, approx. 20 minutes)

Language of assessment: German, English

### Allocation of places

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



# **Seminars Mathematics**

(ECTS credits)



Module	title			Abbreviation		
Seminar in Applied Differential Geometry					10-M=SADG-102-m01	
Module	coord	inator		Module offered by		
Dean of	f Studi	es Mathematik (Mather	natics)	Institute of Mathem	natics	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	n	Module level	Other prerequisites	i		
1 seme	ster	graduate	ning of the course o specified registratio ly be open for stude	r as announced by t on deadlines. Some s ents with previous kn	ide via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain specified in the class schedule.	
Conten	ts					
A mode	rn topi	c in applied differentia	l geometry.			
Intende	ed lear	ning outcomes				
			. ,	•	omprehending and structuring of ate in a scientific discussion.	
Course	<b>S</b> (type, r	number of weekly contact hours	s, language — if other than Ger	rman)		
S (no in	format	ion on SWS (weekly co	ntact hours) and cours	e language available	e)	
		<b>sessment</b> (type, scope, lang le for bonus)	uage — if other than German,	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English						
Allocation of places						
Additio	nal inf	ormation				



Module title Abbreviation							
Semina	Seminar in Algebra				10-M=SALG-102-m01		
Module	coord	inator		Module offered by			
Dean o	f Studi	es Mathematik (Mathem	atics)	Institute of Mathem	natics		
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)			
5	nume	rical grade					
Duratio	n	Module level	Other prerequisites				
1 seme	ster	graduate	ning of the course o specified registratio ly be open for stude	r as announced by the n deadlines. Some sonts with previous kn	ide via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain specified in the class schedule.		
Conten	ts						
A mode	ern topi	ic in algebra.					
Intende	ed lear	ning outcomes					
					omprehending and structuring of ate in a scientific discussion.		
Course	<b>S</b> (type, r	number of weekly contact hours,	language — if other than Ger	rman)			
S (no ir	nformat	tion on SWS (weekly con	tact hours) and cours	e language available	e)		
		<b>sessment</b> (type, scope, langu le for bonus)	age — if other than German,	examination offered — if no	ot every semester, information on whether		
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English							
Allocat	Allocation of places						
Additio	nal inf	ormation					



Module	title			Abbreviation		
Seminar in Dynamical Systems and Control					10-M=SDSR-102-m01	
Module	coord	inator		Module offered by	I	
Dean o	f Studi	es Mathematik (Mathem	natics)	Institute of Mathem	natics	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	n	Module level	Other prerequisites			
1 seme	ster	graduate	ning of the course o specified registratio ly be open for stude	r as announced by the n deadlines. Some s nts with previous kn	ide via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain specified in the class schedule.	
Conten	ts					
A mode	rn topi	c in dynamical systems	and control.			
Intende	ed lear	ning outcomes				
				•	omprehending and structuring of ate in a scientific discussion.	
Course	<b>S</b> (type, r	number of weekly contact hours,	, language — if other than Ger	rman)		
S (no ir	nformat	ion on SWS (weekly cor	ntact hours) and cours	e language available	e)	
		<b>sessment</b> (type, scope, langule for bonus)	age — if other than German,	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English						
Allocation of places						
Additio	nal inf	ormation				



1 1	1911				Tarr	
Modul				Abbreviation		
Semina	ar in Co	mplex Analysis		10-M=SFTH-102-m01		
Module	e coord	inator		Module offered by		
Dean o	f Studi	es Mathematik (Mather	natics)	Institute of Mathem	natics	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme	ster	graduate	ning of the course o specified registratio ly be open for stude	r as announced by the deadlines. Some sonts with previous kn	ide via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain specified in the class schedule.	
Conten	its					
A mode	ern topi	ic in complex analysis.				
Intend	ed lear	ning outcomes				
					omprehending and structuring of ate in a scientific discussion.	
Course	<b>S</b> (type, r	number of weekly contact hours	s, language — if other than Ger	man)		
S (no ii	nformat	tion on SWS (weekly co	ntact hours) and cours	e language available	e)	
		<b>sessment</b> (type, scope, lang ble for bonus)	uage — if other than German,	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English						
Allocation of places						
	-					
Additio	nal inf	ormation				



Modul	o titlo	<u> </u>			Abbreviation	
Seminar in Geometry and Topology					10-M=SGMT-102-m01	
Semin	Seminar in Geometry and Topology				10-101-301011-102-11101	
Modul	e coord	inator		Module offered by		
Dean	of Studi	es Mathematik (Math	ematics)	Institute of Mathen	natics	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Durati	on	Module level	Other prerequisites	i		
Registration for the seminar must be made via SB@ ning of the course or as announced by the lecturer specified registration deadlines. Some seminars or ly be open for students with previous knowledge at areas. Where applicable, details will be specified in			he lecturer in accordance with the seminars or workshops might on- nowledge and/or skills in certain			
Conte	ıts		,			
A mod	ern topi	ic in geometry and top	oology.			
Intend	ed lear	ning outcomes				
			. ,	•	omprehending and structuring of ate in a scientific discussion.	
Course	<b>es</b> (type, r	number of weekly contact ho	urs, language — if other than Ge	rman)		
S (no i	nformat	tion on SWS (weekly o	contact hours) and cours	e language availabl	e)	
		<b>sessment</b> (type, scope, la le for bonus)	nguage — if other than German,	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English						
Allocation of places						
Addition	onal inf	ormation				



Module title Abbreviation						
Giovan	ni-Prod	li Seminar (Master)			10-M=SGPC-102-m01	
Modul	e coord	inator		Module offered by		
Dean c	f Studi	es Mathematik (Mathem	atics)	Institute of Mathen	natics	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme	ester	graduate	ning of the course o specified registratio ly be open for stude	r as announced by t n deadlines. Some s nts with previous kr	nde via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- nowledge and/or skills in certain specified in the class schedule.	
Conter	ıts		_,			
A mod	ern top	ic in the research experti	se of the current hold	er of the Giovanni P	rodi Chair.	
Intend	ed lear	ning outcomes				
					omprehending and structuring of ate in a scientific discussion.	
Course	<b>S</b> (type, r	number of weekly contact hours,	language — if other than Ge	rman)		
S (no i	nforma	tion on SWS (weekly con	tact hours) and cours	e language availabl	e)	
		<b>sessment</b> (type, scope, langu le for bonus)	age — if other than German,	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Language of assessment: English, German if agreed upon with the examiner						
Allocation of places						
Additional information						
Referred to in LPO I (examination regulations for teaching-degree programmes)						



Module title Abbreviation						
Interdi	sciplin	ary Seminar			10-M=SIDZ-102-m01	
Modul	e coord	inator		Module offered by	<del>'</del>	
Dean c	f Studi	es Mathematik (Mathem	atics)	Institute of Mathen	natics	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme	ester	graduate	ning of the course o specified registratio ly be open for stude	r as announced by t n deadlines. Some s nts with previous kr	nde via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- nowledge and/or skills in certain specified in the class schedule.	
Conter	ıts					
A mod	ern top	ic in mathematics with ir	terdisciplinary aspec	ts.		
Intend	ed lear	ning outcomes				
					omprehending and structuring of ate in a scientific discussion.	
Course	<b>es</b> (type, r	number of weekly contact hours,	language — if other than Ger	man)		
S (no i	nforma	tion on SWS (weekly con	tact hours) and cours	e language available	e)	
		sessment (type, scope, langua ble for bonus)	age — if other than German,	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Language of assessment: German, English						
Allocation of places						
Additional information						
Referred to in LPO I (examination regulations for teaching-degree programmes)						



Seminar in Numerical Mathematics and Applied Anal	sis 10-					
		-M=SNMA-102-m01				
Module coordinator	Module offered by					
Dean of Studies Mathematik (Mathematics)	Institute of Mathematic	CS				
ECTS Method of grading Only after suc	c. compl. of module(s)					
5 numerical grade						
Duration Module level Other prerequ	sites					
ning of the co specified regi ly be open for	r the seminar must be made v rse or as announced by the le tration deadlines. Some semi students with previous knowle pplicable, details will be spec	ecturer in accordance with the inars or workshops might on- edge and/or skills in certain				
Contents						
A modern topic in numerical mathematics or applied	nalysis.					
Intended learning outcomes						
The student is able to elaborate a contemporary rese the topic and the available literature, preparing a talk						
Courses (type, number of weekly contact hours, language — if other	an German)					
S (no information on SWS (weekly contact hours) and	course language available)					
<b>Method of assessment</b> (type, scope, language $-$ if other than 0 module is creditable for bonus)	rman, examination offered $-$ if not ever	ry semester, information on whether				
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Language of assessment: German, English						
Allocation of places						
Additional information						
Referred to in LPO I (examination regulations for teaching-degree	programmes)					



Module	title			Abbreviation			
Seminar in Mathematics in the Sciences					10-M=SMNW-122-m01		
Module	coord	inator		Module offered by	I		
Dean of	f Studi	es Mathematik (Mather	matics)	Institute of Mathem	natics		
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)			
5	nume	rical grade					
Duratio	n	Module level	Other prerequisites				
1 seme	ster	graduate	ning of the course o specified registratio ly be open for stude	r as announced by the n deadlines. Some sonts with previous kn	ide via SB@home at the begin- he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain specified in the class schedule.		
Conten	ts						
A mode	rn topi	c in mathematics in the	e sciences.				
Intende	ed lear	ning outcomes					
			, ,	•	omprehending and structuring of ate in a scientific discussion.		
Course	<b>S</b> (type, r	number of weekly contact hours	s, language — if other than Ger	rman)			
S (no in	ıformat	ion on SWS (weekly co	ntact hours) and cours	e language available	e)		
		<b>sessment</b> (type, scope, lang le for bonus)	ruage — if other than German,	examination offered — if no	ot every semester, information on whether		
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English							
Allocation of places							
Additio	nal inf	ormation					



Modul	o titlo				Abbreviation		
Seminar in Optimization					10-M=SOPT-102-m01		
Semin	di ili O <sub>1</sub>	Julilization		v	10-Mi=30F1-102-m01		
Modul	e coord	inator		Module offered by			
Dean	of Studi	es Mathematik (Math	ematics)	Institute of Mathen	natics		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)			
5	nume	rical grade					
Durati	on	Module level	Other prerequisites				
1 seme	ester	graduate	ning of the course o specified registratio ly be open for stude	r as announced by ton deadlines. Some sonts with previous kr	ade via SB@home at the beginhe lecturer in accordance with the seminars or workshops might on- nowledge and/or skills in certain specified in the class schedule.		
Conte	nts						
A mod	ern top	ic in optimisation.					
Intend	ed lear	ning outcomes					
				•	omprehending and structuring of ate in a scientific discussion.		
Course	<b>es</b> (type, r	number of weekly contact ho	urs, language — if other than Ge	rman)			
S (no i	nforma	tion on SWS (weekly o	contact hours) and cours	e language availabl	e)		
		<b>sessment</b> (type, scope, la ble for bonus)	nguage — if other than German,	examination offered — if n	ot every semester, information on whether		
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 90 minutes  Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters.  Language of assessment: German, English							
Alloca	Allocation of places						
Addition	onal inf	ormation					



# **Learning by Teaching Mathematics**

(ECTS credits)



Module title					Abbreviation	
Learning by teaching Mathematics 1					10-M=ELT1-102-m01	
Module coordinator Module offered by						
Dean o	f Studi	es Mathematik (Mathem	atics)	Institute of Mathematics		
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duratio	n	Module level	Other prerequisites			
1 seme	ster	graduate				
Conten	ts					
Superv	ising a	tutorial or study group ir	n the Bachelor's progr	amme under guidar	ice of the respective lecturer.	
Intende	ed lear	ning outcomes				
		ains his/her first experie can apply them in practi		rsity mathematics. F	He/She knows basic didactical	
Course	<b>S</b> (type, r	number of weekly contact hours,	language — if other than Ger	rman)		
Ü (no ir	nforma	tion on SWS (weekly con	tact hours) and cours	e language available	e)	
		<b>Sessment</b> (type, scope, langua le for bonus)	age — if other than German, o	examination offered — if no	ot every semester, information on whether	
		nination (approx. 90 min ssessment: German, Eng				
Allocat	ion of p	olaces				
Additional information						
Referred to in LPO I (examination regulations for teaching-degree programmes)						

# **Compulsory Electives Physics**

(8-32 ECTS credits)



# **Solid State Physics**

(ECTS credits)



Module	title	<u>'</u>			Abbreviation	
Theore	Theoretical Solid State Physics				11-TFK-092-m01	
Module	coord	inator		Module offered by		
Managi and As	_	ector of the Institute of T sics	heoretical Physics	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
8	nume	rical grade				
Duratio	n	Module level	Other prerequisites	s		
1 semester graduate		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.				
Conten	ts					

Principles of Theoretical Solid-State Physics. Fermi liquid theory. Electron-electron interaction. Variational methods. Magnetism. Superconductivity.

### **Intended learning outcomes**

The students have basic knowledge of the theoretical description of solid-state phenomena. They know the corresponding mathematical or theoretical methods and are able to apply them to basic problems of solid-state theory and to understand the connections to experimental results. The individual students have elaborated on an advanced topic of solid-state theory and have discussed this topic in a seminar presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

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### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

**Abbreviation** 



Module title

Theoretical Solid State Physics 2					11-TFK2-111-m01
Module	Module coordinator			Module offered by	
Managing Director of the Institute of Theoretica and Astrophysics			Theoretical Physics	Faculty of Physics and Astronomy	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
8	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester graduate		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		nts about the respective details ion for the course will be consission to assessment. If student admission to assessment over will put their registration for astall prerequisites will be admites subsequent semester. For as-	

### **Contents**

- a) metal-insulators and topological insulators
- b) transport phenomena
- c) magnetic impurities in metals. Kondo effect and heavy fermions
- d) electron-phonon interaction
- e) one-dimensional conductors

### **Intended learning outcomes**

The students have advanced knowledge of the theoretical description of solid-state phenomena. They know the mathematical or theoretical methods and are able to apply them to problems of solid-state theory and understand the connections to experimental results. The individual students have elaborated on an advanced topic of solid-state theory and have discussed this topic in a seminar presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

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### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	e title				Abbreviation
Theory	Theory of Superconduction				11-TSL-092-m01
Module	e coord	inator		Module offered by	
_	Managing Director of the Institute of Th and Astrophysics		heoretical Physics	neoretical Physics Faculty of Physics and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
5	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
1 semester graduate		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			
Conten	its	-			

Introduction to the phenomenom of superconductivity. Microscopic theory of superconductivity (BCS theory).

Phenomenological theory of superconductivity (Ginzburg-Landau theory). Mesoscopic aspects of superconductivity (Andreev scattering, Bobolioubov-de Gennes equation, SQUIDS). Quantum computing with superconductive elements.

# **Intended learning outcomes**

The students have basic knowledge of the theoretical models for the description of superconductivity. They know the properties and application areas of these models and are able to apply calculation methods to simple problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

### Allocation of places

# **Additional information**

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module title					Abbreviation	
Renormalization Group Methods in Field Theory			in Field Theory		11-RMFT-102-m01	
Module	coord	inator		Module offered by		
Managi and As	_		e of Theoretical Physics	Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
Duration  Module level  Gertain prerequisites must be met to qualify for admission to a sessment. The lecturer will inform students about the respectivation to a sessment. The lecturer will inform students about the respectivation of the course. Registration for the course will sidered a declaration of will to seek admission to assessment dents have obtained the qualification for admission to assess the course of the semester, the lecturer will put their registration sessment into effect. Students who meet all prerequisites will ted to assessment in the current or in the subsequent semester sessment at a later date, students will have to obtain the qualidation to assessment anew.			nts about the respective details ion for the course will be consission to assessment. If student admission to assessment over will put their registration for astall prerequisites will be admitted subsequent semester. For as-			
Conten	ts					
Renorm	nalisati	on group methods f	for non-linear partial diffe	ential equations, fiel	ld theoretical contexts and non-	

Intended learning outcomes

analysed behaviour of cryogenic temperatures.

The students gain an overview of non-linearities in partial differential equations and their solution on the basis of the renormalisation group method.

Courses (type, number of weekly contact hours, language - if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module title					Abbreviation
Renorm	Renormalization Theory				11-RNT-092-m01
Module	coord	inator		Module offered by	
Managing Director of the Institute of Th and Astrophysics		neoretical Physics Faculty of Physics and Astronomy		nd Astronomy	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
6	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester graduate		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			

### **Contents**

Renormalisation group methods for Hamiltonian systems. Partial non-linear differential equations with scaling behaviour for dynamics beyond the equilibrium. Classical-critical and quantum-critical phenomena and their relevance for phase diagrams in cryogenic temperatures. Instability of statistical and dynamic mean-field solutions. Stochastic non-linear partial differential equations. Construction of generating functionals. Halperin-Hohenberg-Ma differential equations. Symmetries, e.g. in the stochastic Burgers' equation (KPZ equation). Introduction and comparison of different RG methods.

### Intended learning outcomes

The students have gained an overview of renormalisation group methods for non-linear partial differential equations. They know important examples and corresponding solving methods and are able to apply them to specific tasks.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

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### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title	"			Abbreviation
Many Body Quantum Theory					11-QVTP-092-m01
Module coordinator			Module offered by		
_	Managing Director of the Institute of Th and Astrophysics		heoretical Physics Faculty of Physics and Astronomy		and Astronomy
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
8	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester graduate		sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	trer will inform stude the course. Registrat on of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for	

### **Contents**

This will usually be a course on quantum many particle physics approached by the perturbative methods using Green's functions.

An outline could be:

- 1 Single-particle Green's function
- 2 Review of second quantization
- 3 Diagrammatic method using many particle Green's functions at temperature T=o
- 4 Diagrammatic method for finite T
- 5 Landau theory of Fermi liquids
- 6 Superconductivity
- 7 One-dimensional systems and bosonization

### **Intended learning outcomes**

The students have mastered the principles of quantum field theory in many-particle systems. They are able to apply the acquired methods to current problems of Theoretical Solid-State Physics.

Courses (type, number of weekly contact hours, language - if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

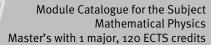
Language of assessment: German, English

### Allocation of places

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### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Modul	e title			Abbreviation		
Relativ	istic Ef	fects in Mesoscopic Sys	tems		11-RMS-092-m01	
Modul	e coord	inator		Module offered by		
	Managing Director of the Institute of Theoretical Physics and Astrophysics			Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
5	nume	rical grade				
Duration	on	Module level	Other prerequisites			
		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.				
Conter	nts					
		fects in mesoscopic syste cors Majorana fermions		oling Dirac equatio	on Quantum Hall effect Topo-	
Intend	ed lear	ning outcomes				
				•	elativistic quantum systems, ledge to simple systems.	
Course	es (type, r	number of weekly contact hours,	language — if other than Ge	rman)		
R + V (	no infor	mation on SWS (weekly	contact hours) and co	ourse language avail	lable)	
		sessment (type, scope, langua ble for bonus)	age — if other than German,	examination offered — if n	ot every semester, information on whether	
groups project (appro Assess and wi examin	s (appro t report x. 30 m sment o Il be an nation r	ox. 30 minutes per candid (approx. 8 to 10 pages, t inutes) ffered: When and how of	date, for modules with ime to complete: 1 to fee assessment will der observance of Sec	h less than 4 ECTS co 4 weeks) or d) preso be offered depends	idate each or oral examination in redits approx. 20 minutes) or c) entation/seminar presentation on the method of assessment 3 ASPO (general academic and	
	tion of p		<u> </u>			

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 

**Additional information** 



Module	e title				Abbreviation
Electro	n Elect	ron Interaction			11-EEW-102-m01
Module	e coord	inator		Module offered by	
_	Managing Director of the Institute of Theoretical Physics and Astrophysics			Faculty of Physics a	nd Astronomy
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
4	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester		graduate	sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	rer will inform stude the course. Registrat n of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in the date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- r admission to assessment over will put their registration for as- t all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for

1. Introduction, systems, Landau theory2. Interacting electron gas. 3. One-dimensional electron gas (without interaction). 4. Introduction to boson phase fields and interactions. 5. Calculation of correlation functions. 6. Method of functional integrals. 7. Renormalisation groups. 8. Consideration of spin. 9. One-dimensional lattice models. 10. Impurities in Luttinger liquids

#### Intended learning outcomes

The students know the principles of the theoretical description of electron-electron interactions in one dimension.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	Module title				Abbreviation
Field Th	neory i	n Solid State Physics			11-FTFK-112-m01
Module	coord	inator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics			heoretical Physics	Faculty of Physics a	nd Astronomy
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
8	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester		graduate	sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	trer will inform stude the course. Registrat on of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for

This will usually be a course on quantum many particle physics using the method of functional integration. An outline could be:

- 1 Coherent states and review of second quantization
- 2 The functional integral formalism at finite temperatures T
- 3 Perturbation theory at T=0
- 4 Order parameters and broken symmetry
- 5 Green's functions
- 6 The Landau theory of Fermi liquids
- 7 Further developments

#### **Intended learning outcomes**

The students have mastered the principles of quantum field theory in many-particle systems. They are able to apply the acquired methods to current problems of Theoretical Solid-State Physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

#### Allocation of places

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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# **Astro Physics and Particle Physics**

(ECTS credits)



Module	title				Abbreviation
Quantu	ım Med	hanics II			11-QM2-092-m01
Module	coord	inator		Module offered by	
Managing Director of the Institute of Theo and Astrophysics			neoretical Physics	Faculty of Physics and Astronomy	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
8	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
		undergraduate	sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	trer will inform stude the course. Registrat on of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for

"Quantum mechanics II" constitutes the central theoretical course of the international Master's program in Physics. It builds upon basics which are acquired in the lecture "Quantum mechanics I" of the Bachelor's degree. While the specific emphasis can be adjusted individually, the core topics that are supposed to be covered should include:

- 1. Second quantisation: Fermions and bosons
- 2. Band structures of particles in a crystal
- 3. Angular momentum, symmetry operators, Lie Algebras
- 4. Scattering theory: Potential scattering, partial wave expansion
- 5. Relativistic quantum mechanics: Klein-Gordon equation, Dirac equation, Loretz group, fine structure splitting of atomic spectra
- 6. Quantum entanglement
- 7. Canonical formalism

#### **Intended learning outcomes**

The students acquire in-depth knowledge of advanced quantum mechanics and have a thorough understanding of the mathematical and theoretical concepts of the listed topics. They are able to describe or model problems of modern theoretical Quantum Physics mathematically, to solve problems analytically, to use approximation methods and to interpret the results physically. The course is pivotal to subsequent theory courses in Astrophysics, High-Energy Physics and Condensed Matter/Solid-State Physics. The course is mandatory for all Master's students.

 $\textbf{Courses} \ (\textbf{type}, \, \textbf{number of weekly contact hours, language} - \textbf{if other than German})$ 

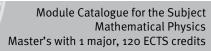
R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English





Allocation of places
Additional information
Referred to in LPO I (examination regulations for teaching-degree programmes)



Module	title				Abbreviation	
Theory	of Rela	ativity			11-RTT-092-m01	
Module	coord	inator		Module offered by		
Managing Director of the Institute of Theoretical Physics and Astrophysics			f Theoretical Physics	Faculty of Physics a	ind Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester		graduate	sessment. The lectuat the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	arer will inform stude the course. Registrat on of will to seek adm d the qualification fo emester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- ents about the respective details cion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for	

Mathematical foundations of the theory of relativity; differential forms; brief summary of special relativity; elements of differential geometry; electrodynamics as an example of a relativistic gauge theory; field equations of general relativity; stellar models; introduction to cosmology; Hamiltonian formulation

#### **Intended learning outcomes**

The students are familiar with the basic physical and mathematical concepts of general relativity. They have a mathematical understanding of the formulation of general relativity on the basis of differential forms. They are able to apply the acquired knowledge to problems of Astrophysics and cosmology.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

Method of assessment (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# Allocation of places

#### **Additional information**

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title				Abbreviation
Genera	l Theor	ry of Relativity			11-ART-112-mo1
Module	coord	inator		Module offered by	1
Managi and Ast		ector of the Institute o	f Theoretical Physics	Faculty of Physics	and Astronomy
ECTS	Metho	od of grading	Only after succ. co	mpl. of module(s)	
4	nume	rical grade			
Duratio	n	Module level	Other prerequisites	S	
certain prerequisites must be met to quasessment. The lecturer will inform student the beginning of the course. Registratical sidered a declaration of will to seek admidents have obtained the qualification for the course of the semester, the lecturer was sessment into effect. Students who meet ted to assessment in the current or in the sessment at a later date, students will have admission to assessment anew.		ents about the respective details ation for the course will be conmission to assessment. If stufor admission to assessment over will put their registration for astet all prerequisites will be admithe subsequent semester. For as-			
ments o	natical of diffe	rential geometry; elec		nple of a relativistic	nmmary of special relativity; elegauge theory; field equations of ulation
Intende	d lear	ning outcomes			
mathen	natical	understanding of the		relativity on the bas	f general relativity. They have a is of differential forms. They are ogy.
Course	<b>5</b> (type, r	number of weekly contact ho	urs, language — if other than Ge	erman)	
V + R (n	o infor	mation on SWS (weel	kly contact hours) and c	ourse language avai	ilable)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

#### Allocation of places

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	Module title				Abbreviation
Specia	l Theor	y of Relativity			11-SRT-112-m01
Module	coord	inator		Module offered by	
Managing Director of the Institute of Theoretical Physics and Astrophysics			Theoretical Physics	Faculty of Physics a	and Astronomy
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
4	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester		graduate	sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effect ted to assessment i	trer will inform stude the course. Registrat on of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for

Mathematical principles; differential forms; special relativity; Minkowski space; Lorentz transformation, Hamiltonian equation of motion; relativistic free particle

## **Intended learning outcomes**

The students are familiar with the physical concepts and mathematical principles of special relativity. They are familiar with modern mathematical formulation of special relativity. They are able to apply the acquired knowledge to problems of special relativity.den.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

## **Allocation of places**

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# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module	e title				Abbreviation
Group 1	Theory				11-GRT-092-m01
Module	e coord	inator		Module offered by	
Managing Director of the Institute of Theoretical Phand Astrophysics			heoretical Physics	Faculty of Physics a	nd Astronomy
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
6	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
1 semester graduate		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		nts about the respective details ion for the course will be consission to assessment. If sturadmission to assessment over will put their registration for astall prerequisites will be admite subsequent semester. For as-	
Conten	its				

Group theory. Finite groups. Lie groups. Lie algebra. Depiction. Tensors. Classification theorem. Applications.

# **Intended learning outcomes**

The students know the basics of group theory, especially of Lie groups. They are able to identify problems of group theory and to solve them by using the acquired methods. They are able to apply group theory to the formulation and processing of physical problems.

Courses (type, number of weekly contact hours, language - if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

## **Allocation of places**

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# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module	title	·		Abbreviation		
Relativ	istical	Quantumfield Theor	у	11-RQFT-092-m01		
Module	coord	inator		Module offered by		
Managing Director of the Institute of The and Astrophysics			of Theoretical Physics	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
8	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester		graduate	sessment. The lecturate the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	es must be met to qualify for admission to as- urer will inform students about the respective details the course. Registration for the course will be con- on of will to seek admission to assessment. If stu- d the qualification for admission to assessment over emester, the lecturer will put their registration for as- t. Students who meet all prerequisites will be admit- n the current or in the subsequent semester. For as- date, students will have to obtain the qualification for sment anew.		

Symmetries. Lagrange formalism for fields. Field quantisation. Gauge principle and interaction. Perturbation theory. Feynman rules. Quantum electrodynamic processes in Born approximation. Radiative corrections and renormalisation.

#### **Intended learning outcomes**

The students have mastered the principles and underlying mathematics of relativistic quantum field theories. They know how to use perturbation theory and how to apply Feynman rules. They are able to calculate basics processes in the framework of quantum electrodynamics in leading order. Moreover, they have a basic understanding of radiative corrections and renormalisation.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title				Abbreviation
Quantu	m Field	d Theory II			11-QFT2-092-m01
Module	coord	inator		Module offered by	
Managi and As		ector of the Institute of Th	neoretical Physics	Faculty of Physics	and Astronomy
ECTS	Metho	od of grading	Only after succ. cor	npl. of module(s)	
6	nume	rical grade			
Duratio	n	Module level	Other prerequisites	1	
1 seme		graduate	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective at the beginning of the course. Registration for the course will be sidered a declaration of will to seek admission to assessment. If dents have obtained the qualification for admission to assessment the course of the semester, the lecturer will put their registration sessment into effect. Students who meet all prerequisites will be ted to assessment in the current or in the subsequent semester. sessment at a later date, students will have to obtain the qualific admission to assessment anew.		ents about the respective details tion for the course will be con- mission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- ne subsequent semester. For as-
		d theory II. Generating fur ntaneous symmetry brea			. Renormalisation group. Gauge
Intende	ed lear	ning outcomes			
The students have advanced knowledge of the methods and concepts of quantum field theory. They have mastered the principles, especially of renormalisation and gauge theories. They are able to formulate and solve simple problems of quantum field theory by using the acquired calculation methods.					
Courses (type, number of weekly contact hours, language — if other than German)					
R + V (no information on SWS (weekly contact hours) and course language available)					
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether					

module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

# **Additional information**

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title				Abbreviation
Particle	Physi	cs (Standard Model)			11-TPS-092-m01
Module	coord	inator		Module offered b	y
		ectors of the Institute of f Theoretical Physics an		Faculty of Physics	s and Astronomy
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
8	nume	rical grade			
Duratio	n	Module level	Other prerequisites	i	
1 seme		graduate	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.		
				ontaneous symme	etry breaking. Experiments on the
		el and determination of	model parameters.		
		ning outcomes	_		
perime	nts tha		confirmed the standa	d model. They are	Particle Physics and the key ex- able to interpret experimental or ty and limits.
Course	<b>S</b> (type, r	number of weekly contact hours	, language — if other than Ge	rman)	
R + V (n	o infor	mation on SWS (weekly	contact hours) and co	ourse language ava	ailable)
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)					
					didate each or oral examination in

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination ir groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title				Abbreviation	
Theoretical Elementary Particle Physics					11-TEP-092-m01	
Module coordinator				Module offered by		
Managi and As	_		of Theoretical Physics	Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
8	nume	rical grade				
Duratio	n	Module level	Other prerequisites	ites		
Duration     Module level       1 semester     graduate			sessment. The lectuat the beginning of sidered a declaration dents have obtaine the course of the sessment into effected to assessment i	urer will inform stude the course. Registrat on of will to seek adm d the qualification fo emester, the lecturer et. Students who mee in the current or in th date, students will h	alify for admission to as- ents about the respective details tion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- ne subsequent semester. For as- eave to obtain the qualification for	
Conten	ts					

Fundamental forces and particles. Groups and symmetries. Quark model. Principles of quantum field theory. Gauge theories. Spontaneous symmetry breaking. Electroweak standard model. Quantum chrome dynamics. Extensions of the standard model.

#### **Intended learning outcomes**

The students are familiar with the mathematical methods of Elementary Particle Physics. They understand the structure of the standard model based on symmetry principles and experimental observations. They know calculation methods for the processing of simple problems and processes of Elementary Particle Physics. Furthermore, they know the tests and limits of the standard model and the basics of extended theories.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title	<b>,</b>			Abbreviation	
Supersymmetry I and II					11-SUS-092-m01	
Module	coord	inator		Module offered by		
Managi and Ast	_	ector of the Institute of sics	Theoretical Physics	neoretical Physics Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester graduate		sessment. The lectuat the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment in	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification fo			

Supersymmetry I: Grassmann variable. Coleman-Mandula theorem and Haag-Lopuszanski-Sohnius theorem. Supersymmetry: Algebra and multiplets. Superfield formalism. Breaking of supersymmetry.

Supersymmetry II: Minimal supersymmetric standard model. Higgs sector. The spectrum of supersymmetric parts.

Supersymmetry II: Minimal supersymmetric standard model. Higgs sector. The spectrum of supersymmetric particles. Phenomenology of LEP, Tevatron and LHC, supersymmetric neutrino mass models. Violation of R-parity.

#### **Intended learning outcomes**

The students have knowledge of the mathematical and physical principles of supersymmetry and supersymmetric models. They understand the theory's formalism and recognise its connections to other models as well as its importance for phenomenology of elementary particles.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	e title			Abbreviation		
Theoretical Astrophysics					11-AST-092-m01	
Module	coord	inator	Module offered by			
Managi and As	_	ector of the Institute of Th	eoretical Physics	Faculty of Physics a	and Astronomy	
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites			
1 seme	ster	graduate				
Conten	ts					
Theore	tical As	trophysics, models for th	e description of com	plex observation res	sults, numeric simulations.	
Intende	ed learı	ning outcomes				
		have basic knowledge of and to test the models wi			. They are able to design complex	
Course	<b>S</b> (type, r	number of weekly contact hours, l	anguage — if other than Ge	rman)		
R + V (r	no infor	mation on SWS (weekly o	contact hours) and co	ourse language avail	able)	
		<b>sessment</b> (type, scope, langua le for bonus)	ge — if other than German,	examination offered — if no	ot every semester, information on whether	
written	examiı	nation (approx. 120 minu	tes)			
Allocat	ion of p	olaces				
Additio	nal inf	ormation				
Referre	d to in	LPO I (examination regulation	s for teaching-degree progra	ımmes)		



Module title					Abbreviation	
Modern Astrophysics					11-MAS-111-m01	
Module	Module coordinator			Module offered by		
Managing Director of the Institute of Theoreti and Astrophysics			neoretical Physics	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
4	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester graduate		sessment. The lecturat the beginning of the sidered a declaration dents have obtained the course of the sessment into effect ted to assessment i	rer will inform stude the course. Registrat n of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- r admission to assessment over will put their registration for as- t all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for		

Introduction to a field of modern Astrophysics, e.g. extra-galactic jets.

## **Intended learning outcomes**

The students know the current state of research on the modern topic of Astrophysics. They know the physical values and are to plan and conduct observations in this area. This includes the ability to conceptualise a specific observational project and e.g. to apply for observation time at large telescopes.

Courses (type, number of weekly contact hours, language - if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

## **Allocation of places**

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# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module	title	<u> </u>			Abbreviation
Cosmology					11-AKM-092-m01
Module	coord	inator		Module offered by	
Managing Director of the Institute of Thand Astrophysics			Theoretical Physics	eoretical Physics Faculty of Physics and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
6	nume	rical grade			
Duratio	n	Module level	Other prerequisites		
1 semester graduate		Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			

Expanding space-time, Friedmannian cosmology, basics of general relativity, the early universe, inflation, dark matter, primordial nucleosynthesis, cosmic microwave background, structure formation, supercluster, galaxies and galaxy clusters, intergalactic medium, cosmological parameters

#### **Intended learning outcomes**

The students have basic knowledge of cosmology. They know the theoretical methods of cosmology and are able to relate them to observations. They have gained insights into current research topics and are able to work on scientific questions.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

 $\textbf{Method of assessment} \ (\textbf{type}, \textbf{scope}, \textbf{language} - \textbf{if other than German, examination of fered} - \textbf{if not every semester, information on whether} \ \\$ module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# Allocation of places

#### **Additional information**

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title			Abbreviation		
Introduction to Plasmaphysics				11-EPP-092-m01		
Module	coord	inator		Module offered by		
Managing Director of the Institute of Thand Astrophysics			of Theoretical Physics	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester graduate		sessment. The lectuat the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment announced.			

Plasma Astrophysics: Dynamics of charged particles in electric and magnetic fields, Magnetohydrodynamics, Transport equations for energetic particles, Properties of magnetic turbulence, Propagation of solar particles within the solar wind, Particle acceleration via shock waves and via interaction with plasma turbulence, Particle acceleration and transport in galaxies and other astrophysical objects, Cosmic radiation.

## **Intended learning outcomes**

The students know the principles of Plasma Physics, especially the description of transport phenomena in plasma. They are able to solve basic problems of Plasma Physics and to apply this knowledge to Astrophysics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	title	<u>,                                      </u>			Abbreviation	
Plasma-Astrophysics					11-APL-092-m01	
Module	coord	inator		Module offered by		
Managi and As	_	ector of the Institute o	f Theoretical Physics	neoretical Physics Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester graduate		sessment. The lectuat the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for			

Plasma Astrophysics: Dynamics of charged particles in electric and magnetic fields. Transport equations for energetic particles. Properties of magnetic turbulence. Propagation of solar particles within the solar wind. Particle acceleration via shock waves and via interaction with plasma turbulence. Particle acceleration and transport in galaxies and other cosmic objects.

#### **Intended learning outcomes**

The students have basic knowledge of Plasma Astrophysics. They have mastered the theoretical description of motion and acceleration of charged particles in space, they know corresponding measuring methods and can compare and evaluate theory and experiments.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	e title			Abbreviation		
Computational Astrophysics				11-NMA-111-m01		
Module	e coord	linator		Module offered by		
Manag and As	_		of Theoretical Physics	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester graduate		sessment. The lectuat the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment in	es must be met to qualify for admission to asurer will inform students about the respective details the course. Registration for the course will be conton of will to seek admission to assessment. If studented the qualification for admission to assessment over emester, the lecturer will put their registration for astact. Students who meet all prerequisites will be admitted in the current or in the subsequent semester. For astact, students will have to obtain the qualification for sment anew.			

Various methods used in astrophysical simulations with special emphasis on their applications. N-body algorithms (tree- and polynomial codes). Particle-mesh methods (particle-in-cell methods). Vlasow methods (e.g., Lattice-Boltzmann). Hyperbolic conservation laws (fluid dynamics, finite difference method, Riemann solver, ENO). Methods of high-performance computing. Message-passing interface (MPI). GPGPU programming (Open-CL).

#### **Intended learning outcomes**

The students are able to solve typical problems and equations of Astrophysics and other subdisciplines of Physics with the help of numerical simulations. They are especially capable of choosing adequate strategies to approach such problems and of validating the results.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 120 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	e title				Abbreviation	
Concep	ts of T	heoretical Astroparticle	physics		11-ATT-111-m01	
Module	coord	inator		Module offered by		
Managi and As	_	ector of the Institute of T sics	heoretical Physics	Faculty of Physics a	nd Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
4	nume	rical grade				
Duratio	n	Module level	Other prerequisites	ther prerequisites		
1 semester graduate		sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment i	trer will inform stude the course. Registrat on of will to seek adm d the qualification fo mester, the lecturer t. Students who mee n the current or in th date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- r admission to assessment over will put their registration for as- t all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for		
Conten	ts					

Concepts of Theoretical Astro-Particle Physics, e.g. Dark matter, cosmic radiation, neutrinos, baryogenesis, cosmic accelerators, dark energy, inflation.

## **Intended learning outcomes**

The students have basic knowledge of the concepts of Theoretical Astroparticle Physics. They are able to describe phenomena of Astroparticle Physics on the basis of methods of Theoretical Physics and to find solution approaches for problems.

 $\textbf{Courses} \ (\textbf{type, number of weekly contact hours, language} - \textbf{if other than German})$ 

V + R (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

## **Allocation of places**

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# Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Module t	itle	<u>'</u>			Abbreviation
Quantum Loop Gravity					11-QSG-102-m01
Module c	oordi	nator		Module offered by	
Managing and Astro	_	ctor of the Institute of Thics	neoretical Physics	Faculty of Physics a	and Astronomy
ECTS N	/letho	d of grading	Only after succ. con	npl. of module(s)	
4 n	umer	ical grade			
Duration		Module level	Other prerequisites		
1 semester graduate		sessment. The lectu at the beginning of t sidered a declaratio dents have obtained the course of the se sessment into effect ted to assessment in	rer will inform stude the course. Registrate n of will to seek admed the qualification for mester, the lecturer to students who meen the current or in the date, students will h	alify for admission to as- nts about the respective details ion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- e subsequent semester. For as- ave to obtain the qualification for	
Contents					

Aside from string theory, quantum loop gravity (QLG) is one of the most important approaches to a quantum mechanical description of gravity. General relativity is formulated in Hamiltonian formalism and the elemental variables are identified with the corresponding Poisson brackets. These variables are quantised in the typical manner on discretised graphs, so-called spin networks. In doing so, e.g. a quantisation of elemental volumes appears. Therefore, QLG belongs to the speculative theories which paint a picture of the constitution of space and time.

#### **Intended learning outcomes**

The students know the principles of quantum loop gravity. They have acquired advanced knowledge of a selected topic and have proved their knowledge in a seminar presentation.

**Courses** (type, number of weekly contact hours, language — if other than German)

V + S (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

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# **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



# **Complex Systems, Quantum control and Biophysics**

(ECTS credits)



Module	e title				Abbreviation	
Physics of Complex Systems					11-PKS-092-m01	
Module	coord	inator		Module offered by		
Managing Director of the Institute of The and Astrophysics			Theoretical Physics	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
6	nume	rical grade				
Duratio	n	Module level	Other prerequisites	Other prerequisites		
1 semester graduate		sessment. The lectuat the beginning of sidered a declaration dents have obtaine the course of the sessment into effected to assessment i sessment at a later	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			

- 1. Theory of critical phenomena in thermal equilibriumt
- 2. Introduction into the physics out of equilibriumt
- 3. Entropy production and fluctuationst
- 4. Phase transitions away from equilibriumt
- 5. Universalityt
- 6. Spin glassest
- 7. Theory of neural networks

# **Intended learning outcomes**

The students have specific and advanced knowledge in the field of physics of complex systems. They know the methods of Statistical Physics, Computational Physics and non-linear dynamics, which are used to describe such systems. They are able to work on current research problems in this area.

 $\textbf{Courses} \ (\textbf{type}, \, \textbf{number of weekly contact hours, language} - \textbf{if other than German})$ 

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

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#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

Master's with 1 major Mathematical Physics (2012)	JMU Würzburg • generated 23-Aug-2021 • exam. reg. da-	page 97 / 126
	ta record Master (120 ECTS) Mathematische Physik - 2012	



Modul	e title				Abbreviation	
Quantı	Quantum Information and Quantum Computing				11-QIC-092-m01	
Module coordinator				Module offered by	l .	
Manag and As			f the Institute of Theoretical Physics Faculty of Physics and Astronomy			
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
Duration     Module level       1 semester     graduate		sessment. The lectuat the beginning of sidered a declaration dents have obtained the course of the sessment into effected to assessment in	urer will inform stude the course. Registrat on of will to seek adn d the qualification fo emester, the lecturer ct. Students who mee in the current or in th date, students will h	alify for admission to asents about the respective details tion for the course will be consission to assessment. If stuber admission to assessment over will put their registration for aset all prerequisites will be admitted subsequent semester. For asease to obtain the qualification for		
Conten	its					

The first part introduces the theoretical concepts of quantum information and quantum computers. It discusses the main quantum algorithms. The second part discusses experimental possibilities for the realisation of entangled states. One of the main topics is the production, controlling and manipulation of coherent two-electron spin states. The third part covers the description and explanation of decoherence of quantum mechanical states.

# Intended learning outcomes

The students have an advanced understanding of quantum theory and basic knowledge of quantum calculation. They are able to solve simple problems of quantum information theory.

**Courses** (type, number of weekly contact hours, language — if other than German)

R + V (no information on SWS (weekly contact hours) and course language available)

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate, for modules with less than 4 ECTS credits approx. 20 minutes) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

#### Allocation of places

#### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



# **Oberseminar**

(ECTS credits)



Modul	e title				Abbreviation	
Advan	ced Ser	ninar Mathematical Phys	sics		11-OSM-122-m01	
Modul	e coord	inator		Module offered by		
Managing Directors of the Institute of Applied Physics and the Institute of Theoretical Physics and Astrophysics				Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
4	nume	rical grade				
Durati	on	Module level	Other prerequisites			
1 seme	ester	graduate				
Contents						
Seminar on current issues of Mathematical Physics.						
Intend	ed lear	ning outcomes				
tract k					atical Physics. They are able to ex- ge and present it to a professio-	
Course	es (type, i	number of weekly contact hours,	language — if other than Ge	rman)		
S (no i	nforma	tion on SWS (weekly cont	tact hours) and cours	e language available	e)	
		sessment (type, scope, langua ble for bonus)	ige — if other than German,	examination offered — if no	ot every semester, information on whether	
		ssion (approx. 30 to 45 r ssessment: German, Eng				
Alloca	tion of	places				
Additio	Additional information					
Referre	ed to in	LPO I (examination regulation	s for teaching-degree progra	ammes)		



# **Compulsory Electives Workshops and Current Topics**

(ECTS credits)



Modul	e title				Abbreviation
Study	Study Group Modern Differential Geometry				11-AG-MMDG-122-m01
Module coordinator				Module offered by	1
chairperson of examination committee		ee	Faculty of Physics	and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
10	nume	rical grade			
Durati	on	Module level	Other prerequisites		
certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective of at the beginning of the course. Registration for the course will be sidered a declaration of will to seek admission to assessment. If sidents have obtained the qualification for admission to assessment the course of the semester, the lecturer will put their registration is sessment into effect. Students who meet all prerequisites will be ted to assessment in the current or in the subsequent semester. It sessment at a later date, students will have to obtain the qualification to assessment anew.		ition for the course will be con- mission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- he subsequent semester. For as-			
	uction t				tion for a Master's thesis in this
		. Summary of the requi	red fundamental topics	in a seminar prese	ntation.
The stu	udents	have advanced knowle	dge of modern differen nmarise their knowledg		ave gained insights into current attack.
Course	<b>es</b> (type, r	number of weekly contact hour	rs, language — if other than Ge	rman)	
S (no information on SWS (weekly contact hours) and course language available)		le)			
		sessment (type, scope, lang ble for bonus)	guage — if other than German,	examination offered — if n	not every semester, information on whether
Assess and wi exami	sment o Ill be an nation r		often assessment will l Inder observance of Sec		on the method of assessment 3 ASPO (general academic and

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**Additional information** 

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Modul	e title				Abbreviation
Study	Study Group Symplectic and Poisson Geometry				11-AG-SPG-122-m01
Modul	Module coordinator			Module offered by	, I
chairp	erson o	f examination commit	tee	Faculty of Physics a	and Astronomy
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)	
10	nume	rical grade			
Duratio	on	Module level	Other prerequisites	i	
	<b>nts</b> uction to		sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effect ted to assessment it sessment at a later admission to assess	the course. Registration of will to seek adressed the qualification for mester, the lecturer t. Students who meen the current or in the date, students will his ment anew.	ralify for admission to as- ents about the respective details tion for the course will be con- mission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- ne subsequent semester. For as- nave to obtain the qualification for as a preparation for a Master's eminar presentation.
Intend	ed lear	ning outcomes	· .	·	·
			edge of Symplectic and o summarise their know		nd have gained insights into cursentation.
Course	es (type, r	number of weekly contact hou	rs, language — if other than Ge	rman)	
S (no i	nformat	tion on SWS (weekly c	ontact hours) and cours	e language availabl	e)
		sessment (type, scope, lan ble for bonus)	guage — if other than German,	examination offered — if n	ot every semester, information on whether
Assess and wi examin	sment o Il be an nation r		often assessment will under observance of Se		on the method of assessment 3 ASPO (general academic and

**Additional information** 

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Modul	e title				Abbreviation	
	Study Group Operator Algebras and Representation Theory				11-AG-OAD-122-m01	
Modul	Module coordinator			Module offered by	I.	
chairp	erson o	f examination committe	e	Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
10	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
	nts uction t	o current questions of o	sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effect ted to assessment is sessment at a later admission to assessment at a later admission to assessment.	rer will inform stude the course. Registrat n of will to seek adn d the qualification for mester, the lecturer t. Students who mee n the current or in the date, students will h sment anew.	ralify for admission to as- rents about the respective details tion for the course will be con- mission to assessment. If stu- or admission to assessment over will put their registration for as- ret all prerequisites will be admit- re subsequent semester. For as- rave to obtain the qualification for as a preparation for a Master's eminar presentation.	
	-	ning outcomes	,			
		have advanced knowled search topics. They are			n theory and have gained insights oral presentation.	
Course	es (type, r	number of weekly contact hours	, language — if other than Ge	rman)		
S (no i	nforma	tion on SWS (weekly co	ntact hours) and cours	e language availabl	e)	
	<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)					
Assess and wi examir	talk with discussion (approx. 30 to 45 minutes) Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009. Language of assessment: German, English					

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**Additional information** 

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 

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Modul	e title	,			Abbreviation
Study	Study Group Hopf Algebras				11-AG-HAL-122-m01
Module coordinator M				Module offered by	
chairperson of examination committee		e	Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
10	nume	rical grade			
Durati	on	Module level	Other prerequisites		
1 Seme		graduate	ate  Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective de at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment the course of the semester, the lecturer will put their registration for sessment into effect. Students who meet all prerequisites will be atted to assessment in the current or in the subsequent semester. For sessment at a later date, students will have to obtain the qualification admission to assessment anew.		ents about the respective details tion for the course will be con- nission to assessment. If stu- or admission to assessment over will put their registration for as- et all prerequisites will be admit- ne subsequent semester. For as-
Conte					
		o current questions of H ne required fundamenta			s thesis in this research area.
Intend	ed lear	ning outcomes			
		have advanced knowled to summarise their knov			nts into current research topics.
Course	<b>es</b> (type, r	number of weekly contact hours,	language — if other than Ge	rman)	
S (no i	nforma	tion on SWS (weekly con	tact hours) and cours	e language availabl	e)
		sessment (type, scope, langu ble for bonus)	age — if other than German,	examination offered — if n	ot every semester, information on whether
Assess and wi examin	sment o Il be an nation r		ften assessment will I der observance of Se		on the method of assessment 3 ASPO (general academic and
	tion of		<del>-</del> ,		
			_		

Additional information

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Modul	e title				Abbreviation	
Study	Study Group Conformal Field Theory				11-AG-KFT-122-m01	
Modul	e coord	linator		Module offered by		
chairp	erson o	of examination committe	ee	Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
10	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme		graduate	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.			
		o current questions of a		as a preparation for	a Master's thesis in this research	
		ry of the required funda			a master 3 thesis in this research	
Intend	ed lear	ning outcomes				
	The students have advanced knowledge of conformal field theory and have gained insights into current research topics. They are able to summarise their knowledge in an oral presentation.					
<b>Courses</b> (type, number of weekly contact hours, language — if other than German)						
S (no information on SWS (weekly contact hours) and course language available)						
		sessment (type, scope, lang ble for bonus)	guage — if other than German,	examination offered — if n	ot every semester, information on whether	
talk wi	talk with discussion (approx. 30 to 45 minutes)					

Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009.

Language of assessment: German, English

# **Allocation of places**

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### **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Modul	e title				Abbreviation
Study	Study Group Statistical Mechanics				11-AG-STM-122-m01
Modul	Module coordinator			Module offered by	1
chairp	chairperson of examination committee		tee	Faculty of Physics	and Astronomy
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)	
10	nume	rical grade			
Durati	on	Module level	Other prerequisites	i	
graduate  Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective at the beginning of the course. Registration for the course will be sidered a declaration of will to seek admission to assessment. If dents have obtained the qualification for admission to assessment the course of the semester, the lecturer will put their registration sessment into effect. Students who meet all prerequisites will be ted to assessment in the current or in the subsequent semester. sessment at a later date, students will have to obtain the qualification to assessment anew.		ation for the course will be con- mission to assessment. If stu- for admission to assessment over r will put their registration for as- cet all prerequisites will be admit- he subsequent semester. For as-			
Introdu		o current questions of	statistical mechanics a	s a preparation for a	a Master's thesis in this research
area. S	Summar	y of the required fund	amental topics in a sem	inar presentation.	
Intend	ed lear	ning outcomes			
			edge of statistical mech their knowledge in an o		ned insights into current research
Course	<b>es</b> (type, r	number of weekly contact hou	ırs, language — if other than Ge	rman)	
S (no i	nforma	tion on SWS (weekly c	ontact hours) and cours	e language availab	le)
		sessment (type, scope, lan ble for bonus)	guage — if other than German,	examination offered — if r	not every semester, information on whether
Assess and wi exami	sment o ill be an nation r		often assessment will under observance of Se		on the method of assessment a 3 ASPO (general academic and

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**Additional information** 

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Modul	e title				Abbreviation
Study	Study Group Quantum Field Theory				11-AG-QFT-122-m01
Modul	e coord	inator		Module offered by	<i>y</i>
chairp	chairperson of examination committee		nittee	Faculty of Physics	and Astronomy
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)	
10	nume	rical grade			
Duratio	on	Module level	Other prerequisites		
certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective at the beginning of the course. Registration for the course will be sidered a declaration of will to seek admission to assessment. If dents have obtained the qualification for admission to assessment the course of the semester, the lecturer will put their registration sessment into effect. Students who meet all prerequisites will be ted to assessment in the current or in the subsequent semester. sessment at a later date, students will have to obtain the qualification to assessment anew.		lents about the respective details ation for the course will be conmission to assessment. If stufor admission to assessment over r will put their registration for asset all prerequisites will be admithe subsequent semester. For as-			
Conter Introdu	_	o current questions	of quantum field theory a	s a preparation for a	a Master's thesis in this research.
			ental topics in a seminar p		
Intend	ed lear	ning outcomes			
			vledge of quantum field t e their knowledge in an o		ned insights into current research
Course	es (type, r	number of weekly contact h	ours, language — if other than Ge	rman)	
S (no i	6 (no information on SWS (weekly contact hours) and course language available)		le)		
		sessment (type, scope, ble for bonus)	language — if other than German,	examination offered — if	not every semester, information on whether
Assess and wi examin	sment o Il be an nation r		ow often assessment will n under observance of Se		s on the method of assessment n 3 ASPO (general academic and

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**Additional information** 

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 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



Modul	e title			Abbreviation		
Study Group Riemannian Geometry					11-AG-RGE-122-m01	
Module coordinator Module offe			Module offered by			
chairp	erson o	f examination commi	ttee	Faculty of Physics a	and Astronomy	
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
10	nume	rical grade				
Duration	on	Module level	Other prerequisites			
ses at t sid der the ses ted ses		sessment. The lecturation at the beginning of sidered a declaration dents have obtained the course of the sessment into effect ted to assessment i	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment appears			
Conter	ıts					
			f Riemannian geometry a damental topics in a sem		a Master's thesis in this research	
Intend	ed lear	ning outcomes				
			ledge of Riemannian geo their knowledge in an o		ned insights into current research	
Course	es (type, r	number of weekly contact ho	urs, language — if other than Ge	rman)		
S (no i	nforma	tion on SWS (weekly	contact hours) and cours	e language availabl	e)	
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)						
talk and discussion (approx. 30 to 45 minutes) Assessment offered: When and how often assessment will be offered depends on the method of assessment and will be announced in due form under observance of Section 32 Subsection 3 ASPO (general academic and examination regulations) 2009. Language of assessment: German, English						
	tion of <sub> </sub>					

**Additional information** 



Module title			Abbreviation				
Study Group Mathematical Physics 11-AG-MPH-122-mo1							
Module coordinator		Module offered by					
chairperson of examination committee Physik (Mathematical Physics)	e Mathematische	Faculty of Physics a	and Astronomy				
ECTS Method of grading	Only after succ. con	npl. of module(s)					
10 numerical grade							
Duration Module level	Other prerequisites	i					
1 semester graduate	Certain prerequisites must be met to qualify for admission to assessment. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.						
Contents							
Introduction to current questions of Ma area. Summary of the required fundam			a Master's thesis in this research				
Intended learning outcomes							
The students have advanced knowledg topics. They are able to summarise the			ned insights into current research				
Courses (type, number of weekly contact hours,	language — if other than Ge	rman)					
S (no information on SWS (weekly cont	tact hours) and cours	e language availabl	e)				
<b>Method of assessment</b> (type, scope, langua module is creditable for bonus)	age — if other than German,	examination offered — if n	ot every semester, information on whether				
talk with discussion (approx. 30 to 45 Assessment offered: When and how of and will be announced in due form undexamination regulations) 2009.  Language of assessment: German, Eng	ften assessment will l der observance of Se						
Allocation of places							
Additional information							

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Modu	le title				Abbreviation	
Study Group Algebra					10-M=GALG-102-m01	
Module coordinator				Module offered by	1	
Dean	of Studi	es Mathematik (Mathe	ematics)	Institute of Mather	matics	
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)		
10	nume	rical grade				
Durati	on	Module level	Other prerequisites	<b>.</b>		
1 sem		graduate	ning of the course of specified registration ly be open for stude	Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.		
Conte	nts					
		ern topics in algebra ( , algebras, division rin		utative algebra, diffe	erential algebra, local fields, com-	
Intend	led lear	ning outcomes				
			emporary research problems		She masters advanced techni-	
Cours	<b>es</b> (type, 1	number of weekly contact hou	ırs, language — if other than Ge	rman)		
V + S (	no info	mation on SWS (week	cly contact hours) and co	ourse language avai	ilable)	
		<b>sessment</b> (type, scope, lar ble for bonus)	nguage — if other than German,	examination offered — if r	not every semester, information on whether	
minar sentat of one Assess semes	present ion of a candid sment o	ration (approx. 60 to 1 pprox. 60 to 120 minu ate each (approx. 20 r ffered: Assessment of	20 minutes), b) written tes, c) written examinat ninutes), e) oral examin fered in the semester ir d or every four semeste	elaboration of conte ion (approx. 90 to 1 ation in groups (gro which the course is	ing methods of assessment: a) se- ents equivalent to a seminar pre- 20 minutes), d) oral examination oups of 2, approx. 30 minutes) s offered and in the subsequent	
Alloca	Allocation of places					

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## **Additional information**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)



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Modul				Abbreviation			
Study	Group I	Discrete Mathematics		10-M=GDIM-102-m01			
Module coordinator				Module offered by			
Dean	of Studi	es Mathematik (Mathem	natics)	Institute of Mathem	natics		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)			
10	nume	rical grade					
Durati	on	Module level	Other prerequisites				
Registration for the seminar must be made via SB@home at the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops make the land of the course			he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain				
Conte	Contents						
Select	ed mod	ern topics in discrete ma	athematics.				
Intend	led lear	ning outcomes					
	_	ains insight into contemes in this field and can a			nematics. He/She masters advan-		
Course	<b>es</b> (type, i	number of weekly contact hours,	, language — if other than Ger	man)			
V + S (	(no info	rmation on SWS (weekly	contact hours) and co	urse language avail	able)		
		<b>sessment</b> (type, scope, langu ble for bonus)	age — if other than German, o	examination offered — if no	ot every semester, information on whether		
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes) Language of assessment: German, English							
Allocation of places							
Additional information							
Referr	ed to in	LPO I (examination regulatio	ns for teaching-degree progra	mmes)			



Module title Study Group Dynamical Systems and Contro Module coordinator Dean of Studies Mathematik (Mathematics)			Abbreviation 10-M=GDSR-102-m01				
Module coordinator  Dean of Studies Mathematik (Mathematics)			10-M=GDSR-102-m01				
Dean of Studies Mathematik (Mathematics)							
· · · · · · · · · · · · · · · · · · ·		Module offered by					
		Institute of Mathem	natics				
ECTS Method of grading Only	y after succ. com	pl. of module(s)					
10 numerical grade							
Duration Module level Other	er prerequisites						
Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with specified registration deadlines. Some seminars or workshops might be open for students with previous knowledge and/or skills in ceareas. Where applicable, details will be specified in the class schedule.							
Contents							
Selected modern topics in dynamical system	ms and control tl	neory.					
Intended learning outcomes							
The student gains insight into contemporary. She masters advanced techniques in this fie							
Courses (type, number of weekly contact hours, language	ge — if other than Ger	man)					
V + S (no information on SWS (weekly conta	act hours) and co	urse language avail	able)				
$\label{eq:method of assessment} \mbox{ (type, scope, language} - \mbox{ if module is creditable for bonus)}$	f other than German, e	examination offered — if no	t every semester, information on whether				
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes) Language of assessment: German, English							
Allocation of places							
Additional information							
Referred to in LPO I (examination regulations for te	eaching-degree progra	mmes)					



Modul	e title				Abbreviation		
Study Group Complex Analysis					10-M=GFTH-102-m01		
Module coordinator				Module offered by			
Dean c	of Studi	es Mathematik (Matl	hematics)	Institute of Mathen	natics		
ECTS	Meth	od of grading	Only after succ. cor	npl. of module(s)			
10	nume	rical grade					
Duratio	on	Module level	Other prerequisites	1			
Registration for the seminar must be made via SB@home at the ning of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops r ly be open for students with previous knowledge and/or skills in areas. Where applicable, details will be specified in the class sc				he lecturer in accordance with the seminars or workshops might on- nowledge and/or skills in certain			
Conter	nts						
			ex analysis (e.g. in approxe distribution theory).	simation theory, pote	ential theory, complex dynamics,		
Intend	ed lear	ning outcomes					
			temporary research probl		lysis. He/She masters advanced		
Course	<b>es</b> (type, r	number of weekly contact h	ours, language — if other than Ge	rman)			
V + S (I	no info	rmation on SWS (wee	ekly contact hours) and co	ourse language avail	lable)		
		<b>sessment</b> (type, scope, l ole for bonus)	anguage — if other than German,	examination offered — if no	ot every semester, information on whether		
minar   sentati of one	present ion of a candid	ation (approx. 60 to pprox. 60 mir	120 minutes), b) written o nutes, c) written examinat o minutes), e) oral examin	elaboration of conte ion (approx. 90 to 12	ng methods of assessment: a) sents equivalent to a seminar pre- 20 minutes), d) oral examination ups of 2, approx. 30 minutes)		
Allocation of places							
Additio	onal inf	ormation					

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module title					Abbreviation			
Study Group Geometry and Topology					10-M=GGMT-102-m01			
Modul	Module coordinator			Module offered by	J.			
Dean	of Studi	es Mathematik (Math	ematics)	Institute of Mathen	natics			
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)				
10	nume	rical grade						
Durati	on	Module level	Other prerequisites	i				
1 semester graduate			ning of the course o specified registratio ly be open for stude	Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.				
Conte	nts							
Select	ed mod	ern topics in geometr	y and topology.					
Intend	ed lear	ning outcomes						
	_	_	emporary research probl can apply them to comp		d topology. He/She masters ad-			
Course	es (type, i	number of weekly contact ho	urs, language — if other than Ge	rman)				
V + S (	no info	rmation on SWS (weel	kly contact hours) and co	ourse language avail	able)			
		<b>sessment</b> (type, scope, la	nguage — if other than German,	examination offered — if no	ot every semester, information on whether			
minar sentat of one	present ion of a candid	tation (approx. 60 to 1 pprox. 60 to 120 minu	20 minutes), b) written e ites, c) written examinat minutes), e) oral examin	elaboration of conte ion (approx. 90 to 12	ng methods of assessment: a) sents equivalent to a seminar pre- zo minutes), d) oral examination ups of 2, approx. 30 minutes)			
Allocation of places								
Addition	onal inf	ormation						



Modul	e title			Abbreviation		
Study Group Measure and Integral					10-M=GMUI-102-m01	
Module coordinator				Module offered by		
Dean o	of Studi	es Mathematik (Mathem	atics)	Institute of Mathem	natics	
ECTS	Meth	od of grading	Only after succ. com	npl. of module(s)		
10	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 semester graduate		Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.				
Conter	nts					
functio	ns and		ected applications, e.	g. product measures	me and measure, measurable s (with Fubini's theorem and the cal spaces.	
Intend	ed lear	ning outcomes				
		ains insight into contemped techniques in this field			integration theory. He/She ma-	
Course	<b>es</b> (type, r	number of weekly contact hours,	language — if other than Ger	rman)		
V + S (1	no info	rmation on SWS (weekly	contact hours) and co	urse language avail	able)	
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)						
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes) Language of assessment: German, English						

Allocation of places

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**Additional information** 

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 $\label{lem:continuous} \textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



	1941				T , ,,			
	Module title Abbreviation  Study Group Numerical Mathematics and Applied Analysis 10 M=GNMA 103 mod							
Study Group Numerical Mathematics and Applied Analysis 10-M=GNMA-102-m01								
Module coordinator				Module offered by				
Dean o	f Studi	es Mathematik (Mathem	natics)	Institute of Mathem	natics			
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)				
10	nume	rical grade						
Duratio	on	Module level	Other prerequisites					
1 semester graduate Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance wis specified registration deadlines. Some seminars or workshops might ly be open for students with previous knowledge and/or skills in ceareas. Where applicable, details will be specified in the class schedule.				he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain				
Conten	Contents							
Selecte	ed topio	cs in numerical mathem	atics, applied analysis	or scientific compu	ting.			
Intend	ed lear	ning outcomes						
		ains insight into a conte ers advanced technique			mathematics or applied analysis. lex problems.			
Course	<b>S</b> (type, r	number of weekly contact hours	, language — if other than Ger	rman)				
V + S (r	no info	rmation on SWS (weekly	contact hours) and co	urse language avail	able)			
		sessment (type, scope, languale for bonus)	age — if other than German, o	examination offered — if no	ot every semester, information on whether			
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes) Language of assessment: German, English								
Allocation of places								
Additio	Additional information							
Referre	ed to in	LPO I (examination regulatio	ns for teaching-degree progra	ımmes)				
		· · · · · · · · · · · · · · · · · · ·						



Madula	- 4:410				ALL voviction		
Module title Abbreviation  Study Group Robotic. Optimization and Control Theory 10-M=GROK-102-m01							
Study Group Robotic, Optimization and Control Theory 10-M=GROK-102-m01							
Module coordinator				Module offered by			
Dean o	f Studi	es Mathematik (Mather	natics)	Institute of Mathem	natics		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)			
10	nume	rical grade					
Duratio	on	Module level	Other prerequisites				
1 semester graduate Registration for the seminar must be made via SB@home at the beg ning of the course or as announced by the lecturer in accordance wi specified registration deadlines. Some seminars or workshops might ly be open for students with previous knowledge and/or skills in cerareas. Where applicable, details will be specified in the class sched				he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain			
Contents							
Selecte	ed mod	ern topics in robotics, c	ptimisation and contro	ol theory.			
Intend	ed lear	ning outcomes					
		ains insight into conten advanced techniques in			imization and control theory. He/ problems.		
Course	<b>S</b> (type, r	number of weekly contact hours	s, language — if other than Ger	rman)			
V + S (1	no info	rmation on SWS (weekly	contact hours) and co	urse language avail	able)		
		sessment (type, scope, lang ble for bonus)	uage — if other than German,	examination offered — if no	ot every semester, information on whether		
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes) Language of assessment: German, English							
Allocation of places							
Additional information							
Referre	ed to in	LPO I (examination regulation	ons for teaching-degree progra	mmes)			



Modul	e title				Abbreviation		
		Mathematics in the So		10-M=GMNW-122-m01			
Module coordinator Module of							
		es Mathematik (Math	ematics)	Module offered by Institute of Mathen	natics		
ECTS	1	od of grading	Only after succ. con	I.	idites		
10	1	rical grade		ipti oi modute(s)			
Durati		Module level	Other prerequisites				
			ning of the course o specified registratio ly be open for stude	Registration for the seminar must be made via SB@home at the beginning of the course or as announced by the lecturer in accordance with the specified registration deadlines. Some seminars or workshops might only be open for students with previous knowledge and/or skills in certain areas. Where applicable, details will be specified in the class schedule.			
Conte	nts						
A mod	ern top	ic in mathematics in t	he sciences.				
Intend	ed lear	ning outcomes					
			emporary research probl nd can apply them to co		in the sciences. He/She masters		
Course	<b>es</b> (type, r	number of weekly contact ho	urs, language — if other than Ge	rman)			
V + S (	no info	rmation on SWS (weel	kly contact hours) and co	ourse language avail	able)		
		sessment (type, scope, landle for bonus)	nguage — if other than German,	examination offered — if no	ot every semester, information on whether		
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups of 2 candidates (approx. 30 minutes) Assessment offered: Assessment offered in the semester in which the course is offered and in the subsequent semester, course offered on demand or every four semesters. Language of assessment: German, English							
	Allocation of places						
Additio	onal inf	ormation					



Module	titla				1	
Ct., d., C.	titte			Abbreviation		
Study Group Number Theory					10-M=GZTH-102-m01	
Module	coordinator			Module offered by		
Dean of	Studies Mathen	natik (Mathema	atics)	Institute of Mathem	natics	
ECTS	Method of grad	ing	Only after succ. com	pl. of module(s)		
10	numerical grade	9				
Duration	n Module l	evel	Other prerequisites			
Registration for the seminar must be made via SB@home at the ning of the course or as announced by the lecturer in accordance specified registration deadlines. Some seminars or workshops r ly be open for students with previous knowledge and/or skills in areas. Where applicable, details will be specified in the class so				he lecturer in accordance with the seminars or workshops might on- lowledge and/or skills in certain		
Content	s					
Selected	d modern topics	in number the	ory (e. g. algebraic nu	mber theory, modul	ar forms, diophantine analysis).	
Intende	d learning outco	omes				
			orary research proble to complex problem		v. He/She masters advanced tech-	
Courses	(type, number of wee	ekly contact hours, l	anguage — if other than Ger	man)		
V + S (no	o information on	n SWS (weekly o	contact hours) and co	urse language avail	able)	
	of assessment (creditable for bonus)	(type, scope, langua	ge — if other than German, e	examination offered — if no	ot every semester, information on whether	
At the beginning of the course, the lecturer will choose one or two of the following methods of assessment: a) seminar presentation (approx. 60 to 120 minutes), b) written elaboration of contents equivalent to a seminar presentation of approx. 60 to 120 minutes, c) written examination (approx. 90 to 120 minutes), d) oral examination of one candidate each (approx. 20 minutes), e) oral examination in groups (groups of 2, approx. 30 minutes) Language of assessment: German, English						
Allocation of places						
Addition	nal information					

**Referred to in LPO I** (examination regulations for teaching-degree programmes)



Module	Module title Abbreviation					
		s in Mathematical Physic	:S		11-EXMP5-122-m01	
				1		
	e coord			Module offered by		
	chairperson of examination committee Mathematische Physik (Mathematical Physics)			Faculty of Physics and Astronomy		
ECTS	Metho	od of grading	Only after succ. compl. of module(s)			
5	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme	ster	graduate	Approval by examin	ation committee req	uired.	
Conten	its					
	Current topics of Mathematical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.					
Intend	ed lear	ning outcomes				
The students have advanced competencies corresponding to the requirements of a module of Mathematical Physics of the Master's programme. They have knowledge of a current subdiscipline of Mathematical Physics and understand the methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.						
Course	Courses (type, number of weekly contact hours, language — if other than German)					
R (no ir	R (no information on SWS (weekly contact hours) and course language available)					
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)						
a) written examination (approx. 120 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)  Language of assessment: German, English						
Allocation of places						
Additio	nal inf	ormation				
<u> </u>						

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



TANK TO RECOURSE OF THE PROPERTY OF THE PROPER						
Module title					Abbreviation	
Curren	t Topic	s in Mathematical Physic	:s		11-EXMP6-122-m01	
Modul	e coord	inator		Module offered by		
	chairperson of examination committee Mathematische Physik (Mathematical Physics)			Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
6	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme	ester	graduate	Approval by examin	ation committee req	juired.	
Conter	nts					
	Current topics of Mathematical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.					
Intend	Intended learning outcomes					
The students have advanced competencies corresponding to the requirements of a module of Mathematical Physics of the Master's programme. They have knowledge of a current subdiscipline of Mathematical Physics and understand the methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.						
Courses (type, number of weekly contact hours, language — if other than German)						
R (no ii	R (no information on SWS (weekly contact hours) and course language available)					
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)						
a) written examination (approx. 120 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)  Language of assessment: German, English						
Allocation of places						
Additio	onal inf	ormation				



TANK TO RECOURSE OF THE PROPERTY OF THE PROPER						
Module title					Abbreviation	
Curren	t Topic	s in Mathematical Physic	:S		11-EXMP7-122-m01	
Modul	e coord	inator		Module offered by		
chairperson of examination committee Mathematische Physik (Mathematical Physics)			Mathematische	Faculty of Physics and Astronomy		
ECTS	Metho	od of grading	Only after succ. con	npl. of module(s)		
7	nume	rical grade				
Duratio	on	Module level	Other prerequisites	1		
1 seme	ster	graduate	Approval by examin	ation committee req	juired.	
Conten	ıts					
	Current topics of Mathematical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.					
Intend	ed lear	ning outcomes				
The students have advanced competencies corresponding to the requirements of a module of Mathematical Physics of the Master's programme. They have knowledge of a current subdiscipline of Mathematical Physics and understand the methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.						
Courses (type, number of weekly contact hours, language — if other than German)						
R (no ii	R (no information on SWS (weekly contact hours) and course language available)					
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)						
a) written examination (approx. 120 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (approx. 8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)  Language of assessment: German, English						
Allocation of places						
Additio	onal inf	ormation				



Module title				Abbreviation		
Current Topics in Mathematical Physics					11-EXMP8-122-m01	
Module	e coord	inator		Module offered by		
chairperson of examination committee Mathematische Physik (Mathematical Physics)			Mathematische	Faculty of Physics and Astronomy		
ECTS	Metho	od of grading	Only after succ. compl. of module(s)			
8	nume	rical grade				
Duratio	n	Module level	Other prerequisites			
1 seme	ster	graduate	Approval by examin	ation committee req	uired.	
Conten	ts		•			
	Current topics of Mathematical Physics. Accredited academic achievements, e.g. in case of change of university or study abroad.					
Intend	ed lear	ning outcomes				
The students have advanced competencies corresponding to the requirements of a module of Mathematical Physics of the Master's programme. They have knowledge of a current subdiscipline of Mathematical Physics and understand the methods necessary to acquire this knowledge. They are able to classify the subject-specific contexts and know the application areas.						
Courses (type, number of weekly contact hours, language — if other than German)						
R (no information on SWS (weekly contact hours) and course language available)						
<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)						
a) written examination (approx. 120 minutes) or b) oral examination of one candidate each or oral examination in groups (approx. 30 minutes per candidate) or c) project report (8 to 10 pages, time to complete: 1 to 4 weeks) or d) presentation/seminar presentation (approx. 30 minutes)  Language of assessment: German, English						
Allocation of places						
Additio	nal inf	ormation				

 $\textbf{Referred to in LPO I} \ \ (\text{examination regulations for teaching-degree programmes})$ 



## **Thesis**

(30 ECTS credits)



Module title					Abbreviation	
Master Thesis Mathematical Physics					11-MA-MP-122-m01	
Modul	e coord	inator		Module offered by		
chairperson of examination committee Mathemati Physik (Mathematical Physics)			Mathematische	Faculty of Physics and Astronomy		
ECTS	Meth	od of grading	Only after succ. con	npl. of module(s)		
30	nume	rical grade				
Duratio	on	Module level	Other prerequisites			
1 seme	ester	graduate				
Conter	nts					
	Mostly independent processing of a task in the field of Mathematical Physics, especially according to known procedures and scientific aspects; writing of the thesis.					
Intend	ed lear	ning outcomes				
	The students are able to independently work on a task from Mathematical Physics, especially according to known methods and scientific aspects and to summarise their results in a final paper.					
Course	<b>es</b> (type, r	number of weekly contact hours,	anguage — if other than Ge	rman)		
no cou	no courses assigned					
	<b>Method of assessment</b> (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)					
written thesis Language of assessment: German, English						
Allocation of places						
Additional information						
Referre	Referred to in LPO I (examination regulations for teaching-degree programmes)					