Module handbook for the degree programmes oft the Department of Mathematics and the Department's teaching service

valid as of Winter Semester 2023/24 in accordance with the resolution of the Departmental Council, dated 07 July 2023

This is a beta version!





Мо	dule na	me									
	Anal	ysis 1									
no.	00-	Credit	Points 9 CP	Workload 270 h	Self-study 165 h	Duration 1 Semester		Frequency Every 2. semester			
	nguage o	of Instr	uction		Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Course	es of the	e Modu	le	•						
	Course	e no.	Course name		Workload	(CP)	Form Teacl		Contact Hours per Week		
	04-00-0	0003-tt	Analysis	s I	0		Conve	ntion	1		
	04-00-0)003-vu	Analysis	s I	0		Lectur Exerci		6		
3	Continue Theore integral Learni After the analyse continue to the continue to	nity, election. ng Outo he compose function.	mentary gral, Function comes on sin consin consist	real numbers, con functions, different andamental Theore of this course, the some real variable us bility and Riemann esults in this conte	ntiation, Mean Van de Mean van	alue The chniques to concept	eorem,	as limi			
4	Requir none	rements	for Pa	rticipation							
5	Final M Usually small r	Module I Modul Standa y the exa number I exam (rd) am is ta of poter (30 min)		ritten test (90 mi	in), exce xam can	pt whe	en there en in tl	e are only a		

	taking the exam.
6	Requirements on the Award of Credit Points Bestehen der Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Bachelor Physics
9	Literature H. Amman, J. Escher: Analysis II, Birkhäuser O. Forster: Analysis I, II. Vieweg M. Hieber: Analysis I, Springer K. Königsberger: Analysis 1, 2, Springer Charles R. MacCluer, Honors Calculus, Princeton Univ. Press W. Rudin: Principles of Mathematical Analysis, McGraw-Hill
10	Comment

Mod	dule nar	ne									
	Analy	ysis 1 (englisc	h)							
Module no. 04-00- 0002		Credit Points 9 CP		Workload 270		f-study 165 h	Duration 1 Semester		Frequency Every 2. semester		
	Language of Instruction English					Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber					
1	Course	s of the	e Modul	e							
	Course	Course no. Cours		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0	040-tt	Analysis	I (english)		0		Conve	ntion	1	
	04-00-0040-vu Analysis I		I (english)	english) 0				e and se	6		
2	Study (Conten	t			•					

	real and complex numbers, convergence of sequences and series, continuity, compactness, elementary functions, differential calculus, Mean Value Theorem, Taylor's Theorem, integral calculus, Fundamental Theorem of Calculus techniques of integration.
3	Learning Outcomes Nach dem Besuch des Moduls können die Studierenden
	- Funktionen einer reellen Variablen mit grundlegenden Konzepten (Grenzwert, Stetigkeit, Differenzierbarkeit, Vollständigkeit usw.) analysieren
	- mathematische Schlussfolgerungen mit verschiedenen Beweismethoden herleiten
4	Requirements for Participation keine
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module 1. Jahr Bachelor
9	Literature H. Amman, J. Escher: Analysis II, Birkhäuser O. Forster: Analysis I, II. Vieweg M. Hieber: Analysis I, Springer K. Königsberger: Analysis 1, 2, Springer Charles R. MacCluer, Honors Calculus, Princeton Univ. Press W. Rudin: Principles of Mathematical Analysis, McGraw-Hill
10	Comment

Mod	dule na	me									
		ysis 2		I	I				T		
Mod no. 04-0	00-	Credit	Points 9 CP	Workload 270 h	Self	elf-study 165 h 1 Seme		Fverv '		2.	
	guage o	of Instru	ıction			son respons . Dr. rer. na					
1	Course	es of the	e Modu	le	l						
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week	
	04-00-0	0002-tt	Analysis	s II		0		Conve	ntion	1	
	04-00-0002-vu Analysi			s II				Lectur Exerci		6	
	Höhere Lokale Lokale Kurven Konver	e Ableitu Extrem Umkeh I, Wege genz vo	a rbarkeit und Vel	nd Satz von Taylo und implizite Fun ktorfelder ierreihen			riablen				
3	After the canalyst continu	e functi iity in n igate ge	oletion on ons in somed s	of this course, the several real variables paces, partial and properties in high	e usi tota	ng fundame l differential	ntal concility and	d integ	rability		
4	-		for Par	rticipation is 1							
5			ination Examina								
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writ	ten Exa	aminati	on,	

Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** Bachelor physics Literature H. Amman, J. Escher: Analysis II, Birkhäuser O. Forster: Analysis I amp; II. Vieweg M. Hieber: Analysis II, Springer K. Königsberger: Analysis 1,2, Springer W. Rudin: Principles of Mathematical Analysis, McGraw-Hill Comment 10

Mod	Module name											
	Analysis 2 (englisch)											
Module no. 04-00- 0004		Credit	Points 9 CP	Workload	270 h		study 165 h	Duration 1 Semester		Frequency Every 2. semester		
Lang Engl	guage o lish	f Instru	action			Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Course	s of the	e Modul	le								
	Course no. Course		e name			Workload	(CP) Forn			Contact Hours per Week		
	04-00-0	011-tt	Analysis	II (english)			0		Conve	ntion	1	

	04-00-0011-vu	Analysis I (englisch)	0	Lecture and Exercise	6
2	Normen, Differ Ableitungsrege Höhere Ableitu Lokale Extrem Lokale Umkeh Kurven, Wege	on Funktionenfolgen, Potenz rentialrechnung mehrerer Va eln, Gradient, ungen und Satz von Taylor in a rbarkeit und implizite Funkt und Vektorfelder on Fourrierreihen	ariablen, partielle Able n mehreren Variablen		,
3	- Funktionen, o (Stetigkeit, tot - geometrische	comes uch des Moduls können die s die von mehreren Variablen ale und partielle Differenzie Zusammenhänge in mehrdi en untersuchen	abhängen, mit grundle rbarkeit, Integration) a	analysieren	
4	Requirements Recommended	for Participation : Analysis I			
5	Standa Usually the exasmall number an oral exam (communicated	Examination: e Examination (Technical Examination) am is taken in form of a write of potential participants. In a second about the two weeks of the lecture, but the second and the second and the second about the second about the second and the second and the second and the second are second as a second and the second are second as a second and the second are second as a second as a second as a second as a second are second as a second are second as a second	ten test (90 min), exce this case, the exam can the form of the exam	ept when there n be taken in tl is taken and	e are only a ne form of
6	Requirements	on the Award of Credit Po	vints		
7		Examination: e Examination (Technical Ex :: 100%, Standard)	kamination, oral / writ	tten Examinati	on,
8	Usability of the Für B.Sc.MCS,	ne Module B.Sc.M\amp;E,: Pflicht Für	B.Sc.Math, B.Sc.Math	(bilingual), B.:	Sc.WiMa,

	LaG.Math: als Alternative zu Analysis 2
9	Literature
	H. Amman, J. Escher: Analysis II, Birkhäuser
	O. Forster: Analysis I amp; II. Vieweg
	M. Hieber: Analysis II, Springer
	K. Königsberger: Analysis 1,2 , Springer
	W. Rudin: Principles of Mathematical Analysis, McGraw-Hill
10	Comment

Mod	dule nan	ne									
	Linea	r Alge	bra 1								
no. 04-0			Points 9 CP	Workload 270 h	Self	-study 165 h	study Duration 165 h 1 Semes		Freque Every 2 semest	2.	
Language of Instruction German						on respons Dr. rer. nat			odule		
1	Courses	s of the	e Modu	le							
	Course no. Cour		Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-00	042-tt	Linear A	Algebra I	0		Conve	ntion	1		
	04-00-00	042-vu	Linear A	Algebra I		0		Lecture and Exercise		6	
2	Study Content basic notions and concepts, algebraic structures (groups, rings, fields); vector spaces, linear dependence, bases, dimension; linear and affine subspaces, products, sums and quotients, dual space; linear maps and matrices; determinants; systems of linear equations										
3											

anzuwenden, mit geometrischen Begriffen in Verbindung zu bringen, typische Aufgaben

zu lösen und einfache Beweise zu führen.

4	Requirements for Participation keine
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Grundstudium Mathematik
9	Literature Bosch: Lineare Algebra Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie Fischer: Lineare Algebra Greub: Linear Algebra (auch deutsch) Koecher: Lineare Algebra und Analytische Geometrie
10	Comment

Mod	Module name												
	Linear Algebra 1												
Mod no. 04-0	00-	Credit	Points 9 CP	Workload	270 h		- study 165 h	Duratio 1 Semes		Frequent Every 2. semeste			
Lan	guage	of Instru	ıction			Pers	on respons	ible for t	the M	odule			
Eng	lish					Prof	. Dr. rer. nat	t. Martin	Otto				
1	Course	es of the	e Modul	le									
	Course no. Course name			mornioud (Gr)		Form of Teaching		Contact Hours per					

					Week					
	04-00-0041-tt	Linear Algebra I	0	Convention	1					
	04-00-0041-vu	Linear Algebra I	0	Lecture and Exercise	6					
2	Study Conten	<u> </u> t		Exercise						
_	T	and concepts, algebraic s	structures (group	s, rings, fields);						
	vector spaces,	linear dependence, base	es, dimension;							
	linear and affii	ne subspaces, products,	sums and quotie	nts, dual space;						
	linear maps an	nd matrices;								
	determinants;									
	systems of line	ear equations								
3	Students will be in various contour In particular, to notions of line them with geo	Learning Outcomes Students will be able to recognise the concepts of linear algebra in various contexts, and to apply and explain them. In particular, they will have learnt to apply abstract-axiomatic notions of linear algebra to typical problems, to connect them with geometric concepts, to solve typical problems and to conduct simple proofs.								
4	Requirements keine	s for Participation								
5	Form of Exam Final Module I • Modul Standa	Examination: le Examination (Technic	al Examination,	oral / written Examinati	ion,					
6	Requirements	s on the Award of Cred	it Points							
7		Examination: le Examination (Technic :: 100%, Standard)	eal Examination,	oral / written Examinati	ion,					
8	Usability of the									
9	Literature Bosch: Lineare Brieskorn: Line	e Algebra eare Algebra und Analyt	ische Geometrie							

	Bröcker: Lineare Algebra und Analytische Geometrie Fischer: Lineare Algebra Greub: Linear Algebra (auch deutsch) Koecher: Lineare Algebra und Analytische Geometrie
10	Comment

Mod	dule na	me								
	Line	ar Alge	bra 2		1				1	
Moo no. 04-0		Credit	Points 9 CP					on ster	Frequency Every 2. semester	
	guage o man	of Instru	ıction			son respons . Dr. rer. nat			odule	
1	Course	es of the	e Modul	le	•					
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0	0008-tt	Linear A	Algebra II		0 Con			ntion	1
	04-00-0	0008-vu	Linear A	Algebra II					Lecture and 6 Exercise	
2	eigenva charact Jordan euclide bilinea possibl	teristic a normal can and r forms,	d diago an minir form; unitary quadra sions: af	nalisation of endonal polynomials in spaces; tic forms, quadricular and projective and algebra	n the	ring of univa	-			
3	Learning Outcomes Die Studierenden erlernen zentrale Konzepte und Techniken der linearen Algebra und erfahren das Zusammenspiel zwischen abstrakt-axiomatischen Begriffsbildungen der Algebra und ihrer Rolle in diversen Bereichen der Mathematik,									

hier insbesondere durch Anknüpfungen an geometrische Begriffe.

4	Requirements for Participation
	Lineare Algebra 1
5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Standard)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	Grundstudium Mathematik
9	Literature
	Bosch: Lineare Algebra
	Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie
	Fischer: Lineare Algebra
	Greub: Linear Algebra (auch deutsch)
	Koecher: Lineare Algebra und Analytische Geometrie
10	Comment

Mod	Module name										
	Linear Algebra 2										
Module no. Credit Points Workload 04-00- 9 CP 270							- study 165 h	Duratio 1 Semes		Frequent Every 2. semeste	
Lan	guage (of Instru	ıction			Person responsible for the Module					
Eng	lish					Prof	Dr. rer. na	t. Martin	Otto		
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Forn Teac		Contact Hours per

1	1		ı		ı
					Week
	04-00-0012-tt	Linear Algebra II	0	Convention	1
	04-00-0012-vu	Linear Algebra II	0	Lecture and Exercise	6
2	Study Content	t			
	eigenvalues an	d diagonalisation of endomo	orphisms;		
	characteristic a	nn minimal polynomials in th	e ring of univari	iate polynomials;	
	Jordan normal	form;			
	euclidean and	unitary spaces;			
	bilinear forms,	quadratic forms, quadrics;			
	-	sions: affine and projective g multilinear algebra	eometry, geomet	try of conic sections	,
3	in various cont In particular, the notions of lines	be able to recognise the conc exts, and to apply and expla hey will have learnt to apply ar algebra to typical problen metric concepts, to solve typ	in them. abstract-axioma	ntic	
4	Requirements Lineare Algebr	for Participation a 1			
5	Form of Exam Final Module E				
	Modul Standa:	e Examination (Technical Exrd)	amination, oral	/ written Examinati	ion,
6	Requirements	on the Award of Credit Po	ints		
7		Examination: e Examination (Technical Ex : 100%, Standard)	amination, oral	/ written Examinati	ion,
8	Usability of th Grundstudium				
9	Literature Bosch: Lineare	Algebra			

Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie Fischer: Lineare Algebra Greub: Linear Algebra (auch deutsch) Koecher: Lineare Algebra und Analytische Geometrie Comment

Module Description

10

Module name **Ordinary Differential Equations** Module Frequency no. Credit Points | Workload Self-study Duration Every 2. 04-00-4 CP 120 h 75 h 1 Semester semester 0011/f Person responsible for the Module Language of Instruction Prof. Dr. rer. nat. Matthias Hieber German **Courses of the Module** Course name Workload (CP) Form of Contact Course no. Teaching Hours per Week 3 04-00-0054-vu | Ordinary Differential Equations | 0 Lecture and Exercise 2 **Study Content** Separation of variables, Theorems of Picard-Lindelöf and Peano, local and global theory, linear systems of first and higher order, variation of constants formula, linearised stability, Lyapunov stability. 3 **Learning Outcomes** Nach dem Besuch des Moduls

- können sie die Methode der Trennung der Variablen
- sind sie mit den Sätzen von Picard-Lindelöf und Peano vertraut
- sind sie mit der lokalen und globalen Existenztheorie gewöhnlicher

Differentialgleichungen vertraut

- können sie lineare Systeme erster und höherer Ordnung analysieren
- können Sie die Variation der konstanten Formel entwickeln
- können sie das Prinzip linearisierter Stabilität formulieren und anwenden
- sollten sie den Begriff der Lyapunov Stabilität erklären und auf konkrete Beispiele anwenden können

Requirements for Participation Empfohlen: Analysis und Lineare Algebra (für Physikstudierende) 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung: Usually the exam is taken in form of a written test (60 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (20 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Bestehen der Fachprüfung 7 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module 8 **Bachelor Physics** Literature H. Amann: Gewöhnliche Differentialgleichungen, de Gruyter W.Walther: gew. DGL, Springer Comment 10

Mod	lule na	ıme						
	Com	nplex Analysis						
Mod no. 04-0	00-	Credit Points 4 CP	Workload 120 h	Self-study 75 h	Duration 1 Semester	Frequency Every 2. semester		
Language of Instruction German				Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber				
1	Courses of the Module							

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
	04-00-0225-vu	Complex Analysis	0	Lecture and Exercise	3
2	Theorem and I	nn differential equations, curv Formula; analyticity, Liouville' gebra; Winding Number; Laur	s Theorem and Fund	lamental	5,
3	- sind sie mit d	comes uch des Moduls en Cauchy-Riemannschen Diff urvenintegrale analysieren und		vertraut	
	vertraut und - sind sie mit d - können sie d - können sie La - können sie is	em Cauchyschen Integralsatz können deren Implikationen a er Bedeutung der Potenzreihe en Satz von Liouville und den aurentreihen analysieren olierte Singularitäten anhand Residuensatz und dessen Imp	ufzeigen n in der Funktionen Hauptsatz der Algeb konkreter Beispiele e	theorie vertrau ora erklären	
4	Requirements Analysis and L	for Participation inear Algebra			
5	Form of Exam Final Module I • Modul Standa	Examination: e Examination (Technical Exa	mination, oral / writ	tten Examinati	on,
	there are only taken in the fo taken and com	t two weeks of the lecture, bas	articipants. In this ca The decision about t	se, the exam che form of the	ean be exam is
6	Requirements Passing the Fa	on the Award of Credit Poir	nts		
7	Grading Final Module I	Examination:			

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	Bachelor Physics
9	Literature Freitag: Funktionentheorie I, Springer Remmert: Funktionentheorie I, Springer Conway: Functions of one complex variable, Springer
10	Comment

Mod	lule naı	me								
	Pros	eminar	ı							
Module no. Credit F 04-00- 0025		Points 4 CP	Workload 120 h	Self-study 90 h		Duration 1 Semester		Every 2		
Lan g Geri	guage o	of Instru	action			son respons liendekan*ii				
1	Course	es of the	e Modu	le	•					
	Course	e no.	Course	e name					n of hing	Contact Hours per Week
	04-00-0	047-ps	Prosemi	nar		0		Proser	ninar	2
2	A simple The sultheme.	bject ma The ser	is assign atter ma minar m	ned to individual s y vary with the in ay have a project to the seminar.	struc	tor's choice o	of a gene	eral		
3	Learning Outcomes Die Studenten können eine Literaturrecherche durchführen, sich ein mathematisches Thema im Selbststudium aneignen und dieses in einem Vortrag anschaulich präsentieren. Gegebenenfalls können sie den Sachverhalt auch schriftlich angemessen darstellen.									
4	Requirements for Participation Analysis und Lineare Algebra									

5	Form of Examination
	Final Module Examination:
	Module Examination (Study Examination, Special Form, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	Für B.Sc.Math, B.Sc.WiMa, B.Sc.MCS, B.Sc.ME: Pflicht
9	Literature
	wird je nach Thema angegeben
10	Comment
	Verantwortlich: Studiendekan

Mod	lule na	me											
	Pros	eminar											
no.	4-00- 4 CP		Credit Points		Credit Points V		Workload 120 h			Duration 1 Semester		Frequency Every 2. semester	
Lang Engl		of Instru	ıction			on respons liendekan*ir							
1	Course	es of the	e Modu	le									
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week			
	04-00-0	147-ps	Prosem	inar (engl.)		0		Proser	ninar	2			
2	Study Content A simple topic is assigned to individual students or to small groups of students. The subject matter may vary with the instructor's choice of a general theme. The seminar may have a project format. Each participant gives a one hour presentation to the seminar.												

3	Learning Outcomes In der Vorbereitungsphase: Fähigkeit zu Literaturrecherche, Selbststudium, Auswahl der Präsentationstechniken, Arbeitsorganisation. Beim Vortrag: Fähigkeit zu anschaulicher Darstellung durch freie Rede, Erfahrung beim Einsatz von Präsentationstechniken, Fähigkeit, auf die Zuhörer einzugehen. Von Seiten der Hörer: Befähigung zu aktiver und fairer Diskussion über Inhalte und Darstellung. Gegebenenfalls Erlernen einer angemessenen schriftlichen Darstellung der Ergebnisse.
4	Requirements for Participation Analysis 1,2 und Lineare Algebra 1,2
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module Für B.Sc.Math, B.Sc.Math (bilingual), B.Sc.WiMa, B.Sc.MCS, B.Sc.ME: Pflicht
9	Literature wird je nach Thema angegeben
10	Comment Verantwortlich: Studiendekan

Module na	me								
Intro	Introduction to Mathematical Logic								
Module no. 04-00-	Credit Points 9 CP	Workload 270 h	Self-study 180 h	Duration 1 Semester	Frequency Every 2. semester				
0028	f In atmostice		Danaan waan ana	ible for the NA					
English	of Instruction		Person respons Prof. Dr. phil. na						

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per
	04-00-0148-vu	Introduction to Mathematical	0	Lecture and	Week 6
_		Logic		Exercise	
2	completeness logical and set	t mantics of first-order logic; for theoren; compactness theoren theoretic foundations of mat ry; undecidability and incomp	n, hematics; elementar		
3	can use them i with the conce foundations of	comes re familiar with basic concepts in the context of classical theo ept of formal proofs. They kno mathematics and can also dis e relevant theorems.	rems for first-order in the significance of	logic and in co f first-order log	nnection gic in the
4	_	s for Participation ine mathematische Vorbildun	g		
5	Form of Exam Final Module I Modul Standa	Examination: le Examination (Technical Exa	amination, oral / wri	itten Examinati	ion,
6	Requirements	s on the Award of Credit Poi	nts		
7		Examination: le Examination (Technical Exa t: 100%, Standard)	amination, oral / wri	itten Examinati	ion,
8		ne Module , B.Sc.Math (bilingual), B.Sc.N n Wahlpflichtbereich Für M.Sc		-	reich
9	Ebbinghaus, F. Shoenfield: M. Cori, Lascar: N	neben vielen anderen Lehrbüdlum, Thomas: Einführung in dathematical Logic; Mathematical Logic; Se in Model Theory, an Introd Logic	lie mathematische L		

10	Comment

Mod	dule na	me								
	Alge	bra								
Mod no. 04-0	dule		Points 9 CP	Workload 270 h	Self-study 180 h		Duration 1 Semester		Every 2	
	guage (man	of Instru	action			son respons . Dr. rer. na				
1	Course	es of the	e Modul	le		1		1		
	Course no. Cours		Cours	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0	0080-vu	Algebra			0		Lectur Exerci		6
2	1	Conten polynor		gs, field extensions	, Gal	ois theory, n	nodules			
3	After a theory,	, have ir	g the mo	odule, students und to the theory of m			_		-	
4	_		for Par	rticipation ebra						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
6	Requirements on the Award of Credit Points									
7	Gradir Final M	U	Examina	ition:						

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Für B.Sc.Math, B.Sc.Math (bilingual), B.Sc.MCS, B.Sc.WiMa, B.Sc.ME:
	Wahlpflichtbereich. Für M.Sc.Math: Vertiefungsbereich. Für M.Sc.WiMa: Ergänzungsbereich.
9	Literature
	Jantzen, Schwermer: Algebra,
	Bosch: Algebra, Lang: Algebra,
	Hungerford: Algebra
10	Comment

Mod	lule na	me							
	Alge	bra							
no. 04-0	Module		- study 180 h	Duratio 1 Semes		Freque Every 2 semest	2.		
Lan Engl		of Instru	action		on respons Dr. rer. nat				
1	Course	es of the	e Modu	le					
	Course no.		Cours	e name	Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)149-vu	Algebra		0		Lectur Exerci		6
2	Rings, Polyno Field e	Contenmial rinxtension theory,	.gs,						
3	After a	-	g the mo	odule, students un to the theory of m		_		_	

	and their applications.
4	Requirements for Participation Module: Lineare Algebra, Einführung in die Algebra
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Für B.Sc.Math, B.Sc.Math (bilingual), B.Sc.MCS, B.Sc.WiMa, B.Sc.ME: Wahlpflichtbereich. Für M.Sc.Math: Vertiefungsbereich. Für M.Sc.WiMa: Ergänzungsbereich.
9	Literature Jantzen, Schwermer: Algebra, Bosch: Algebra, Lang: Algebra, Hungerford: Algebra
10	Comment

Mod	lule na	me									
	Discrete Mathematics										
no. 04-0	Module Frequency										
Lan	guage (of Instru	ıction			Pers	on respons	ible for 1	the M	odule	
Geri	man					Prof. Dr. rer. nat. Marc Pfetsch					
1	Courses of the Module										
	Course	e no.	Course	e name		·	Workload	(CP)	Form	of	Contact

				Teaching	Hours per Week
	04-00-0137-vu	Discrete Mathematics	0	Lecture and Exercise	6
2	Permutation graphs project series Other to regular tilings	t ed sets: lattices, Möbius furoups: group actions on (five planes Generating functions): triangular of the plane; graph colorings of the symmetric group	inite) sets and getions: solving retions of convex p	raphs, Cayley ecursions, hypergeome polygons;	tric
3	o recognize dis	comes ce of the module, the stud screte structures with far r general foundations for alg nt concepts of counting.	eaching relation		thematics,
4	_	s for Participation screte mathematics			
5	Form of Example Final Module I Module Standa	Examination: e Examination (Technical	Examination, oi	ral / written Examinati	ion,
6	Requirements	on the Award of Credit	Points		
7		Examination: e Examination (Technical) :: 100%, Standard)	Examination, oi	ral / written Examinati	ion,
8	Usability of th	e Module			
9	M. Aschbacher N. Biggs, Algel R. L. Graham, edition, Addiso W. Koepf, Hyp and Special Fu	krete Mathematik, 5. Aufla F, Finite Group Theory, Car Draic Graph Theory, Secon D. E. Knuth and O. Patash on-Wesley, Reading, MA, 1 ergeometric Summation. A Inction Identities, AMS, 19 I. Nešetril, Diskrete Mather	mbridge, 1986. d Edition, Camb nik, Concrete M 994. An Algorithmic A 98.	oridge, 1993. athematics, Second Approach to Summatio	n

	R.P. Stanley, Enumerative Combinatorics, Volume I, Cambridge 1997.
10	Comment

		_								
Mod	dule na	me								
	Func	tional	Analysi	s						
Mod no. 04-0	00-	Credit	Points 9 CP	Workload 270 h			Duration 1 Semester		Frequency Every 2. semester	
	guage c man	of Instru	action			son respons . Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no. Course name					Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0	069-vu	Functio	nal Analysis		0		Lectur Exerci		6
2	normal the ope	en mapp gence; S ar opera	aces; con oing, of Sobolev	mpletion; Hahn-Ba the closed graph; l spaces; weak solu ompact operators o	Hilbe tion (ert spaces; re of the Dirich	flexive s let probl	paces; lem; sp	weak ectral p	oroperties
3	Learning Outcomes After attending the module, students will be able to - combine ideas of linear algebra, analysis and topology - determine the interaction of space and dual space and in applications determine them exemplarily - explain functional analytical methods in the context of partial differential equations									
4	Requirements for Participation Analysis, Integrationstheorie, Funktionentheorie, Lineare Algebra oder vergleichbare Vorkenntnisse aus einem Zyklus Mathematik für Ing.									
5		of Exam Iodule I								

	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module for B.Sc.Math, B.Sc.MCS, B.Sc.WiMa, B.Sc.ME: math. Elective for M.Sc.Math, M.Sc.WiMa: supplementary area in partial differential equations and in algebra/geometry/functional analysis is required
9	Literature Alt: Lineare Funktionalanalysis; Conway: A Course in Functional Analysis; Heuser: Funktionalanalysis; Reed, Simon: Functional Analysis: Methods of Modern Mathematical Physics I; Rudin: Functional Analysis; Werner: Funktionalanalysis;
10	Comment

Mod	Module name										
	Elementary Partial Differential Equations										
Module no. 04-00- 0039		Credit	Points 6 CP	Workload	180 h			Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German Person responsible for the Module Prof. Dr. rer. nat. Jens Lang											
1	Courses of the Module Course no. Course name				Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0153-vu Elementary Partial Differentary Equations		Different	tial	0		Lectur Exerci	-	4		

2 Study Content

classification of partial differential equations, method of characteristics, explicit representations of solutions of the wave equation and the heat equation, physical interpretation; fundamental solutions and reen's function for elliptic differential equations, maximal principle; explicit solutions in terms of Fourier series in special dommains

3 Learning Outcomes

Nach dem Besuch des Moduls können die Studierenden

- die Grundtypen linearer partieller Differentialgleichungen mit klassischen und expliziten Lösungsmethoden untersuchen
- Mathematische Modelle zur Behandlung grundlegender naturwissenschaftlicher und technischer Problemstellungen aufstellen und analysieren

4 Requirements for Participation

Module: Analysis und Lineare Algebra, gewöhnliche Differentialgleichungen, Integration

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

Für B.Sc.CE: Pflicht Für B.Sc.Math, B.Sc.MCS: math. Wahlbereich (B) Für B.Sc.WiMa, B.Sc.ME: math. Wahlbereich Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich auch in den Studiengängen der Fachbereiche Physik, Mechanik, Chemie, Maschinenbau, Bauingenieurwesen, Elektotechnik und Informationstechnik

9 Literature

John: Partial Differential Equations Jost: Partielle Differentialgleichungen Strauss: Partielle Differentialgleichungen

Sauvigny: Partielle Differentialgleichungen der Geometrie und Physik. Band

1: Grundlagen und Integraldarstellungen

10	Comment

Mod	lule na	me								
	Intro	ductio	n to Op	otimization						
no.	4-00- 9 CP				-study 180 h	Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German					Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch					
1	Course	es of the	e Modul	le						
	Course no. Course name					Workload (CP) For Tea			n of hing	Contact Hours per Week
	04-00-0	0023-vu	Introdu	ction to Optimizatio	n	0		Lectur Exerci		6
	Study Content convex sets and functions; introduction to polyhedral theory; optimality and duality theory of linear optimization; simplex-algorithm for the solution of linear optimization problems; polynomial complexity of linear optimization; methods for quadratic optimization problems									
3	After a theory theory solutio	of linea and the n metho	ce of the r optimic theory ods for l	e module, the studization and can ap of convex function inear and quadrativation p	ply tl is. Th ic opt	nem. They a ney know the imization pr	re famili e fundan roblem. T	ar witl nental Γhey c	h polyhe numerio an modo	edral cal el and
4	-			rticipation Lineare Algebra						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
6	Requir	ements	on the	Award of Credit	Poin	ts				

7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	Für B.Sc.WiMa, B.Sc.Mamp;E: Pflicht Für B.Sc.Math, B.Sc.MCS: Wahlpflichtbereich
	Mathematik (C*) Für M.Sc.Math: Ergänzungsbereich Für B.Sc.CE: als mathematisches Wahlmodul wird in der Mastervertiefung Optimierung vorausgesetzt
	wanimodul wird in der mastervertierung Optilmerung vorausgesetzt
9	Literature
	Chvatal: Linear Programming
	Geiger; Kanzow: Theorie und Numerik restringierter Optimierungsaufgaben;
	Jarre, Stoer: Optimierung
	Nocedal; Wright: Numerical Optimization;
	Schrijver: Theory of Linear and Integer Programming;
	Schrijver. Theory of Emeal and integer Programming,
	Ziegler: Lectures on Polytopes
10	Comment

Mod	lule naı	me								
	Prob	ability	Theory	1						
010415101		Points 9 CP	Workload 270 h		- study 180 h	Duration 1 Semester		Frequency Every 2. semester		
Language of InstructionPerson responsible for the ModuleGermanProf. Dr. rer. nat. Frank Aurzada										
1	Course	es of the	e Modu	le		1				
	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0	141-vu	Probabi	lity Theory		0		Lectur Exerci	-	6
2	•	Content re theor		oundations, theory	of in	tegration, ra	ındom v	ariable	es,	

concepts of convergence, characteristic functions, stochastic independence, 0-1-laws, conditional expectations, martingales in discrete time, limit theorems: law of large numbers, central limit theorem

3 Learning Outcomes

After completion of this module, the students are expected to

- know the basic concepts and constructions of measure theory and probability theory,
- be able to apply these concepts to simple models,
- know the central results of probability theory and are able to describe their consequences in simple models,
- are able to model random phenomena mathematically.

4 Requirements for Participation

Module: Analysis, Integration, Einführung in die Stochastik

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination,
 Weight: 100%, Standard)

8 Usability of the Module

Für B.Sc.WiMa, B.Sc.M\amp;E: Pflicht

Für B.Sc.Math, B.Sc.MCS: Wahlpflichtbereich Mathematik (D*)

Für M.Sc.Math: Ergänzungsbereich

Für B.Sc.CE: im mathematischen Wahlpflichtbereich A

Für M.Sc.CE: Bereich 1B wird in der Mastervertiefung Stochastik vorausgesetzt.

9 Literature

Bauer: Probability Theory

Billingsley: Probability and Measure Elstrodt: Maß-und Integrationstheorie Gänssler, Stute: Wahrscheinlichkeitstheorie

Klenke: Wahrscheinlichkeitstheorie

10 Comment

Verantwortlich: Herr Aurzada (sto)

Mod	lule na	me									
	Prob	ability	Theory	,							
no.	4-00- 9 CP			Self-study 180 h		Duration 1 Semester		Frequency Every 2. semester			
Lan	Language of Instruction				Person responsible for the Module						
Eng	lish				Prof	Dr. rer. na	t. Frank	Aurzao	la		
1	1 Courses of the Module										
	Course no. Course		e name	: name Work		- (-)		n of hing	Contact Hours per Week		
	04-00-0	0071-vu	Probabi	lity Theory		0		Lectur Exerci		6	
3	concepts of convergence, characteristic functions, stochastic independence, 0-1-laws, conditional expectations, martingales in discrete time, limit theorems: law of large numbers, central limit theorem. Learning Outcomes Nach dem Besuch des Moduls können die Studierenden										
	Nach dem Besuch des Moduls können die Studierenden - die grundlegenden Konzepte und Konstruktionen der Maß- und Wahrscheinlichkeitstheorie beschreiben und an einfachen Modellen anwenden, - die zentralen Ergebnisse der Wahrscheinlichkeitstheorie und ihre Konsequenzen										
	beschro und ii		hen Mo	dellen anwenden,							
	- zufäll	ige Phä	nomene	mathematisch mo	odelli	eren und an	alysierer	1.			
4	_			ticipation gration, Einführur	ng in	die Stochast	-ik				
5			ination Examina								

	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Für B.Sc.WiMa, B.Sc.ME: Pflicht Für B.Sc.Math, B.Sc.MCS: Wahlpflichtbereich Mathematik (D*) Für M.Sc.Math: Ergänzungsbereich Für B.Sc.CE: im mathematischen Wahlpflichtbereich A Für M.Sc.CE: Bereich 1B wird in der Mastervertiefung Stochastik vorausgesetzt.
9	Literature Bauer: Probability Theory Billingsley: Probability and Measure Elstrodt: Maß-und Integrationstheorie Gänssler, Stute: Wahrscheinlichkeitstheorie Klenke: Wahrscheinlichkeitstheorie
10	Comment Verantwortlich: Herr Aurzada (sto)

Mod	Module name										
	Project in Mathematics										
Module no. 04-00- 0053		Credit	Points 6 CP	Workload	180 h			1 Semester		Frequency Every 2. semester	
Ger	man	of Instru					on respons iendekan*ir				
1	Courses of the Module Course no. Course name			Workload	(CP)	Form Teac	-	Contact Hours per Week			
2	Study	Conten	t								

A small group works on a complex problem. The formulation of the problem may be open ended; a final precise and focussed fomulation may be a part of the project. The concrete subject matter content will depend on the problem. Regular reports describe the work in progress. In conclusion, there will be a presentation in which the results are described and discussed. A report in writing, preferably in LATEX, will record and document the results of the project. **Learning Outcomes** Die Studierenden können für eine konkrete Problemstellung Lösungsstrategien entwickeln und umsetzen. Sie können eine umfangreiche Aufgabe in Teilschritte gliedern, Zwischenzielen formulieren, sinnvolle Teilaufgaben definieren, und geeignet präsentieren. Je nach Thema können sie auch experimentell arbeiten und Software anwenden. **Requirements for Participation** nach Angabe 5 Form of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Passed / Not Passed) **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed) **Usability of the Module** Für B.Sc.Math, B.Sc.WiMa, B.Sc.MCS, B.Sc.ME: alternativ zum Seminar. Kann als Ausgangspunkt einer Bachelorarbeit dienen. Literature ie nach Thema Comment 10 Verantwortlich: Studiendekan

Mod	lule na	me									
	Proje	ect in M	lathem	atics							
		Duration 1 Semester		Frequency Every 2. semester							
Lan Eng	guage d	of Instru	action		Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	Course	s of the	e Modu	le							
	Course	e no.	Cours	e name		Workload (CP) Form Teacl		_	Contact Hours per Week		
2	A small group works on a complex problem. The formulation of the problem may be open ended; a final precise and focussed fomulation may be a part of the project. The concrete subject matter content will depend on the problem. Regular reports describe the work in progress. In conclusion, there will be a presentation in which the results are described and discussed. A report in writing, preferably in LATEX, will record and document the results of the project.										
3	Lösung Projekt Aufteil Präsent	manage ung von tationste	gien für ement: (Aufgab echnike:	konkrete Problems Gliederung in Teils ben an die Team-M n, je nach Thema a zuwenden.	chrit Iitglie	te, Formulie eder, Auswal	rung vor hl geeign	Zwis eter	chenziel		
4	Requir nach A		for Pa	rticipation							
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed)										
6	Requirements on the Award of Credit Points										
7	Grading Final Module Examination:										

	Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	Für B.Sc.Math, B.Sc.WiMa, B.Sc.MCS, B.Sc.ME: alternativ zum Seminar. Kann als Ausgangspunkt einer Bachelorarbeit dienen.
9	Literature
9	Literature wird je nach Thema spezifiziert
9	
9	
	wird je nach Thema spezifiziert

Mod	lule na	me										
	Appl	ied Pro	of The	ory	•							
Module no. 04-00- 0058		Credit Points 9 CP		Workload 270 h	Self	-study 180 h	Duration 1 Semester		Frequency Every 2. semester			
Language of Instruction English						Person responsible for the Module Prof. Dr. phil. nat. Ulrich Kohlenbach						
1	Course	es of the	e Modu	le	•							
	Course no. Cou		Cours	se name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0)166-vu	Applied	Proof Theory		0		Lecture and Exercise		6		
2	Study Content This course gives an introduction to the area of applied proof theory. The course focuses on so-called proof interpretations which extract computational data from (even prima facie ineffective) proofs by recursion on the proof. Table of contents: no-counterexample interpretation, intuitionistic logic, negative translation, Gödel functional interpretation, monotone functional interpretation, elimination of König's lemma, applications to proofs in analysis.											
3	Learning Outcomes Introduction to one of the active research areas in applied logic with a particular emphasis on proof-theoretic, model-theoretic resp. categorical methods.											
4	_			rticipation hematische Logik	Nützl	lich: Introdu	ction to	Comp	utability	Theory.		

5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	Für M.Sc.Math: zusammen mit passender Ergänzung als Vertiefung Logik Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich
9	Literature Kohlenbach, Ulrich: Proof Interpretations and the Computational Content of Proofs. Lecture notes (320pp). Draft of book project.
10	Comment

Module name											
Discrete Optimization											
Module no. 04-00- 0073		Credit Points 9 CP		Workload 270 h	Self-study 180 h		Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German 1 Courses of the Module					Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch						
1	Course no.		Course name		Woı	Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0027-vu		Discrete Optimization		0		Lectur Exerci		6		
2	•	Study Content modeling; integral equation and inequality systems; theory: integer programs, polyhedral									

	combinatorics; methods: exact solution methods, approximation algorithms, heuristics, relaxations
3	Learning Outcomes After attendance of the module, the students are able to handle the theoretical foundations of discrete optimization. The students additionally are able to model problems and analyze and apply relevant algorithms.
4	Requirements for Participation Introduction to Optimization, Algorithmic Discrete Mathematics
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc.Math, M.Sc.WiMa: Vertiefung Optimierung M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich M.Sc.CE: B2
9	Literature Nemhauser, Wolsey: Integer and Combinatorial Optimization Schrijver: Theory of Linear and Integer Programming
10	Comment

Module na	ame				
Pro	ject in Mathem	atics (Master)			
Module no.	Credit Points	Workload	Self-study	Duration	Frequency
04-00- 0080	6 CP	180 h	180 h	1 Semester	Every 2. semester

	nguage of Instruman	uction		on responsible fo iendekan*in des Fa		ŀ
1	Courses of the	e Module	-1			
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week
2	ended; a final subject matter progress. In co	works on a complex problem precise and focussed fom content will depend on the onclusion, there will be a page of A report in writing, preference.	ulation ne pro presen	n may be a part of blem. Regular repo tation in which tho	the project. Thorts describe the results are de	ne concrete ne work in escribed
3	eine konkrete Sie können ein Zwischenzieler und geeignet p	den können für Problemstellung Lösungss ne umfangreiche Aufgabe in n formulieren, sinnvolle T präsentieren. n können sie auch experin	in Tei 'eilauf	lschritte gliedern, gaben definieren,	d umsetzen.	
4	Requirements nach Angabe	s for Participation				
5	Form of Exam Final Module I • Modul		amina	tion, Special Form	, Passed / Not	: Passed)
6	Requirements	s on the Award of Credit	Point	ts		
7	Grading Final Module I Modul Not Pa	le Examination (Study Exa	amina	tion, Special Form	, Weight: 100%	∕₀, Passed /
8		ne Module , B.Sc.WiMa, B.Sc.MCS, B tt einer Bachelorarbeit die		\amp;E: alternativ	zum Seminar.	. Kann als
9	Literature je nach Thema	1				

10 Comment

Verantwortlich: Studiendekan

Mod	dule na	me									
	Proje	ect in M	lathem	atics							
Mod no. 04-0		Credit	Points 6 CP	Workload 180 h		- study 180 h	Duratio 1 Semes	Every '		2.	
Lan	guage (of Instru	ıction		Pers	on respons	ible for	the M	odule		
Eng	lish				Stud	liendekan*ii	n des Fac	hbere	ichs 04		
1	Course	es of the	e Modu	le							
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
2	Eine komplexe Problemstellung wird durch kleine Gruppen bearbeitet. Das Thema darf offen formuliert sein und erst während der Bearbeitung präzisiert oder fokussiert werden. Die fachlichen Inhalte sind themenabhängig. Über den Fortgang der Projektbearbeitung wird regelmäßig berichtet. Den Abschluss bildet eine Projektpräsentation, in der die Ergebnisse vorgestellt und diskutiert werden. Gegebenenfalls werden die Ergebnisse schriftlich ausgearbeitet; dabei soll ein wissenschaftliches Schreibsystem wie LaTeX angewendet werden.										
3	Learning Outcomes Lösungsstrategien für konkrete Problemstellungen entwickeln, erlernen von Projektmanagement: Gliederung in Teilschritte, Formulierung von Zwischenzielen, Aufteilung von Aufgaben an die Team-Mitglieder, Auswahl geeigneter Präsentationstechniken, je nach Thema auch experimentelles Arbeiten und die Fähigkeit, geeignete Software anzuwenden.										
4	_			rticipation ch Angabe							
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed)										
6	Requir	ements	on the	Award of Credit	Point	ts					

7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module Vertiefungsbereich (Studienleistung) alternativ zum Seminar. Ergänzungsbereich (benotete Prüfungsleistung, nur nach vorheriger Anmeldung und Genehmigung);
9	Literature wird je nach Thema spezifiziert
10	Comment Verantwortlich: Studiendekan

Mod	lule na	me								
	Four	ndation	s of Te	aching and Lear	ning	of Mathem	natics			
Module no. Cred 04-00- 0087		Credit	redit Points 8 CP Workload 240 h		Self-study Dura 180 h 2 Se			Duration 2 Semester		e ncy 2. er
Language of InstructionPerson responsible for the ModuleGermanProf. Dr. phil. nat. Katja Krüger										
1	Course	es of the	e Modu	le						
	Course no. Co		Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)107-ps		zed didactics for aduates		0		Proseminar		0
	04-00-0)179-vu	Teachin Mathen	g and Learning of natics		0		Lectur	re	4
2	Study Content Models of teaching Mathematics, management of heterogeneity, theory of tasks, learning goals and content of math-teaching in schools with reasons, methods of long-term development of competences									
3	The stu	e typica	re able l math-t	to use different the eaching and learn tasks to support c	ing si	ituations for	heterog	eneou	s learnii	ng groups;

	reasons for a choice of goals and content of learning environments
4	Requirements for Participation Mathematics as common language of the natural sciences, Analysis, Linear Algebra, or equivalent (participation without certification of prerequisites is possible)
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) • Module Examination (Technical Examination, Special Form, Standard)
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistungen is a prerequisite for taking the Fachprüfung
7	 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
8	Usability of the Module Mathematics: Teaching degrees
9	Literature Bruder, R., Hefendehl-Hebeker, L., Schmidt-Thieme, B. Weigand, HG. (Hrsg.)(2015). Handbuch der Mathematikdidaktik. Springer Berlin Heidelberg. Bruder, R., Büchter, A. Leuders, T.(2008). Mathematikunterricht entwickeln. Bausteine für kompetenzorientiertes Unterrichten. Cornelsen Scriptor.
10	Comment

Module na	ame				
Geo	metry for Tead	hers			
Module no.	Credit Points	Workload	Self-study	Duration	Frequency
04-00- 0091	6 CP	180 h	120 h	1 Semester	Every 2. semester

	guage of Instru	uction		son responsible fo		ckmann			
1	Courses of the	e Module	FIOI	. Dr. Ter. Hat. Karsı	.en Große-Drau	CKIIIaIIII			
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-00-0110-vu	Geometry (for Teaching Degrees)		0	Lecture and Exercise	4			
2	Keplersche Ges	eometrie: Geraden, Dreiec	-			nnitte,			
3	Die Studierend	Learning Outcomes Die Studierenden kennen und verstehen die elementargeometrischen Grundbegriffe und Methoden und können diese auf typische Fragestellungen anwenden.							
4	Requirements for Participation								
5	Form of Exam Final Module I • Modul Standa	Examination: le Examination (Technical	Exar	nination, oral / wr	itten Examinati	ion,			
6	Requirements	on the Award of Credit	Poin	ts					
7		Examination: le Examination (Technical :: 100%, Standard)	Exar	nination, oral / wr	itten Examinati	ion,			
8	Usability of th	ne Module							
9	Literature								
10	Comment								

Mod	dule na	me								
	Geor	metry f	or Tead	hers and DGS o	nline	training				
Mod no. 04-0		Credit	Points 7 CP	Workload 210 h		- study 150 h	Duratio 1 Seme		Freque Every semest	2.
	Language of Instruction German					son respons				ckmann
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0)110-vu	Geomet Degrees	ry (for Teaching		0		Lectur Exerci		4
	04-00-0)266-pr	DGS on	line training		0		Praction Lab / Intern		0
2	•	Conten Teilmod		ometrie für das Lel	hram	t" und "DGS	-Praktik	um on	line"	
3		ng Out o		ometrie für das Lel	hram	t" und "DGS	-Praktik	um on	line"	
4	_			rticipation ometrie für das Lel	hram	t" und "DGS	-Praktik	um on	line"	
5			ination Examina							
	•	Modul	e Exam	ination (Technical	Exar	nination, Te	chnical i	Examiı	nation,	Standard)
	Course	Examir	nation:							
	•	[04-00)-0266-p	or] (Study Examin	ation	, Study Exar	nination	ı, Pass	ed / No	ot Passed)
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradin Final M	•	Examina	ntion:						
	•		e Exam Standar	ination (Technical [.] d)	Exar	nination, Te	chnical i	Examiı	nation,	Weight:

	Course Examination:
	• [04-00-0266-pr] (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	Pflichtmodul
9	Literature
	Siehe Teilmodule "Geometrie für das Lehramt" und "DGS-Praktikum online"
10	Comment

Mod	lule na	me								
	Scho	ol Prac	tical St	udies II - Mather	natio	cs				
Module no. Credit I 04-00- 0093		Points 5 CP	Workload 150 h	3		Duration 1 Semester		Frequency Every 2. semester		
Language of InstructionPerson responsible forGermanProf. Dr. phil. nat. Katja										
1	Course	es of the	e Modu	le						
	Course no. Course name						Form Teac	_	Contact Hours per Week	
	04-00-0	0044-se		l training in schools nematics	II	0		Semin	ar	2
2	Monito	•		ing mathematical lign.	lesso	ns, didactica	l and me	ethodio	cal	
3	Learning Outcomes Die Studierenden beobachten, planen Unterricht, führen diesen durch und reflektieren ihn anhand fachdidaktischer Kriterien verfassen Unterrichtsentwürfe mit didaktischer und methodischer Analyse setzen sich mit einem fachdidaktischen Schwerpunktthema tiefergreifend auseinander arbeiten mit einer Lernplattform und dokumentieren ihre Praktikumszeit									

	in einem online-Portfolio
	verfassen einen Praktikumsbericht.
4	Requirements for Participation Pflichtmodul "Grundlagen des Lehrens und Lernens von Mathematik" absolviert
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	Literature Barzel, B., Holzäpfel, L., Leuders, T., Streit, C. (2011). Scriptor Pra- xis - Mathematik: Mathematik unterrichten: Planen, durchführen, reflektie- ren: Buch mit Kopiervorlagen. Cornelsen Verlag Scriptor. Kretschmer, H. Stary, J. (1998). studium kompakt - Pädagogik: Schulpraktikum: Eine Ori- entierungshilfe zum Lernen und Lehren. Studienbuch. Cornelsen Lehrbuch Meyer, H. (2004). Praxisbuch: Was ist guter Unterricht? Mit didaktischer Landkarte. Cornelsen Verlag Scriptor.
10	Comment

Module n	Module name										
Mathematics I (Civil Engineering)											
Module no. 04-00- 0104/f	Credit Points 8 CP		Self-study 150 h	Duration 1 Semester	Frequency Every 2. semester						
Language German	of Instruction		Person respons	ible for the M	Iodule						

1	Courses of the Module										
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week						
	04-00-0120-vu	Calculus I (civil engineering)	0	Lecture and Exercise	6						
2	systems of line	t blex numbers, vectors, scalar a ear equations, linear maps, ma ences and series, differential	atrices, determinants	s, eigenvalues,	orthogonal						
3	Nachdem Stud Begriffsbildung Veränderlicher geometrische I beschreiben. S und in ihrer Be	earning Outcomes achdem Studierende das Modul besucht haben, können sie die grundlegenden egriffsbildungen und Resultate der linearen Algebra und der Analysis einer eränderlicher wiedergeben, ihre inhaltlich-logischen Beziehungen und ihre eometrische Bedeutung erklären und ihre Rolle in den Naturwissenschaften eschreiben. Sie können die wichtigsten zugehörigen rechnerischen Methoden anwenden nd in ihrer Bedeutsamkeit und Zuverlässigkeit beurteilen. Sie können sich im späteren tudium und Beruf die benötigten mathematischen Kenntnisse selbst erarbeiten.									
4	Requirements	s for Participation									
5	Form of Exam Final Module I • Modul Standa	Examination: le Examination (Technical Ex	amination, Written E	Cxam, Duration	90 min,						
6	Requirements	on the Award of Credit Po	ints								
7	Grading Final Module I Modul Standa	e Examination (Technical Ex	amination, Written E	Exam, Weight:	100%,						
8	Usability of th	ne Module									
9		Lehn, Schellhaas, Wegmann is und Lineare Algebra, 4. Au		matik für Inger	nieure						
		8. 7. 1. 1.									

Module Description		

Mod	dule na	me								
	Calcı	ulus I (d	ivil eng	gineering)						
no. 04-0	Module no. Credit Points Workload 04-00- 8 CP 240 h		Self	-study 150 h	Duratio 1 Seme		Freque Every 2 semeste	2.		
	guage o	of Instru	uction		Pers	son respons	ible for	the M	odule	
1	Course	es of the	e Modul	le						
	Course	e no.	Course	e name		Workload	(CP)	Forn Teac	_	Contact Hours per Week
	04-00-0)120-vu	Calculu	s I (civil engineering	;)	0		Lectur Exerci		6
3	different series,	ntial and numerion	d integrated integrate	nbers, vectors, scal al calculus in one v gration. das Modul besuch	varia	ble, fundam	ental the	eorem	of calcui	lus, Taylor
	Begriff inhaltli beschro und in	sbildung ich-logis eiben. S ihrer Be	gen und schen Be ie könne edeutsar	Resultate der Ana eziehungen erkläre en die wichtigsten mkeit und Zuverläste benötigten mathe	lysis n un zuge ssigk	einer Verän d ihre Rolle hörigen recl eit beurteile	derliche in den N nnerisch n. Sie kö	r wied Vaturw en Me onnen s	ergeben rissensch thoden a sich im s	, ihre naften anwenden späteren
4	Requir keine	ements	for Pa	rticipation						
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, oral / written Examination, Standard)									
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradi r Final M	_	Examina	tion:						

	Module Examination (Study Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht für B.Sc.BIGeo: zusammen mit Mathematik II in zwei getrennten Prüfungen
9	Literature
	v. Finkenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure Band I, Analysis und Lineare Algebra, 4. Aufl., Teubner, 2006.

Mod	dule na	me								
	Matl	hemati	cs II (Ci	vil Engineering)						
Mod no. 04-0		Credit Points 8 CP		Workload 240 h	Self	-study 150 h	Duration 1 Semester		Frequency Every 2. semester	
	guage o	of Instru	action		Pers	son respons	ible for	the M	odule	
1	Course	es of the	e Modu	le	•					
	Course no. Course name				Workload (CP)		Teaching		Contact Hours per Week	
	04-00-0)074-vu	Calculu	s II (civil engineerin	g)	0		Lectur Exerci		6
2	Taylor		Fourier :	series, Differential ls, integration ove			•			
3	Nachdo Begriff Analys und ih Veränd Sie kör	Learning Outcomes Nachdem Studierende das Modul besucht haben, können sie die grundlegenden Begriffsbildungen und Resultate der Theorie der Taylor- und Fourier-Reihen und der Analysis mehrerer Veränderlicher wiedergeben, ihre inhaltlich-logischen Beziehungen und ihre geometrische Bedeutung erklären. Sie können Begriffe der Analysis mehrerer Veränderlicher wiedererkennen und ihre Rolle in den Naturwissenschaften beschreiben. Sie können die wichtigsten zugehörigen rechnerischen Methoden anwenden und in ihrer Bedeutsamkeit und Zuverlässigkeit beurteilen. Sie können sich im späteren Studium und								

	Beruf die benötigten mathematischen Kenntnisse selbst erarbeiten.
4	Requirements for Participation Recommended: Mathematik I (04-00-0104/f)
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Written Exam, Duration 90 min, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, Written Exam, Weight: 100%, Standard)
8	Usability of the Module
9	Literature v. Finkenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure Band I, Analysis und Lineare Algebra, 4. Aufl., Teubner, 2006.
10	Comment

Mod	Module name												
	Calculus II (civil engineering)												
Mod no. 04-0	00-	Credit	Points 8 CP	Workload	240 h		study 150 h	Duratio 1 Semes		Frequei Every 2. semeste			
l	Language of Instruction German					Person responsible for the Module							
1	Cours	es of the	e Modul	le									
	Cours	e no.	Course	e name			Workload	(CP)	Forn Teac	-	Contact Hours per Week		

	04-00-0074-vu	Calculus II (civil engineering)	0	Lecture and Exercise	6							
2	Study Content Linear algebra: systems of linear equations, matrices, determinants, eigenvalues, orthogonal matrices, quadratic forms and conic sections; differential calculus of functions of several variables: Integration of functions of several variables: integration over 2 and 3-dimensional domains, path integrals, surface integrals, integral theorems.											
3	Learning Outcomes Nachdem Studierende das Modul besucht haben, können sie die grundlegenden Begriffsbildungen und Resultate der Vektorrechnung und Linearen Algebra wiedergeben, ihre inhaltlich-logischen Beziehungen und ihre geometrische Bedeutung erklären. Sie können Begriffe der Linearen Algebra in der Analysis mehrerer Veränderlicher wiedererkennen und ihre Rolle in den Naturwissenschaften beschreiben. Sie können die wichtigsten zugehörigen rechnerischen Methoden anwenden und in ihrer Bedeutsamkeit und Zuverlässigkeit beurteilen. Sie können sich im späteren Studium und Beruf die benötigten mathematischen Kenntnisse selbst erarbeiten.											
4	Requirements Mathematik I	for Participation										
5	Form of Exam Final Module I • Modul		nation, oral / written	Examination,	Standard)							
6	Requirements	on the Award of Credit Poi	nts									
7		Examination: e Examination (Study Examir Standard)	nation, oral / written	Examination,	Weight:							
8	Usability of the Pflicht für B.Sc Prüfungen	ne Module c.BauGeo: zusammen mit Mat	hematik I in zwei ge	trennten								
9	Literature v. Finkenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure Band I, Analysis und Lineare Algebra, 4. Aufl., Teubner, 2006.											
	Comment											

Module name

Mathematics III (Civil Engineering)

IVIGE		ivii Engineering,	1		
Module no. 04-00- 0106/f	Credit Points 8 CP	Workload 240 h		Duration 1 Semester	Frequency Every 2. semester
Language	of Instruction		Person respons	ible for the M	odule
German					

1 Courses of the Module

doubles of the module										
Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week						
04-00-0121-vu	Calculus III (civil engineering)	0	Lecture and Exercise	6						

2 Study Content

- 1) Differential equations:
- a) First order ordinary differential equations existence and uniqueness, numerical methods;
- b) Second order ordinary differential equations linear differential equations with constant and variable coefficients, systems of linear differential equations;
- c) Partial differential equations classification, product ansatz, Fourier series;
- 2) Calculus of variations;
- 3) Probability theory conditional probabilities, random variables and distribution functions, mean and variance, central limit theorem;
- 4) Statistics:
- a) descriptive statistics;
- b) estimation techniques and confidence intervals unbiasedness and consistency, maximum likelihood estimate;
- c) statistical tests tests assuming Gaussian distribution, chi^2 test of goodness of fit, analysis of variance;

3 Learning Outcomes

Im Rahmen des für ihren Studiengang Erforderlichen sollen die Studierenden über Vertrautheit mit den einfachsten Typen von Differentialgleichungen und den Anfangsgründen der Stochastik verfügen. Die Studierenden besitzen die Fähigkeit, die wichtigsten rechnerischen Methoden in ihrer Bedeutsamkeit beurteilen und auf ingenieurtechnische Fragen, insbesondere im späteren Studium und Beruf anwenden zu können. Sie besitzen Grundvoraussetzungen,

	sich die benötigten mathematischen Kenntnisse selbst anzueignen.
4	Requirements for Participation Recommended: Mathematik I and II (04-00-0104/f/ 04-00-0105/f)
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Written Exam, Duration 90 min, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, Written Exam, Weight: 100%, Standard)
8	Usability of the Module
9	Literature wird zu Beginn der VL bekannt gegeben.
10	Comment

Mod	Module name										
	Calculus III (civil engineering)										
Mod no. 04-0	00-	Credit	Points 6 CP	Workload	180 h	l	study 90 h	Duratio 1 Seme		Freque Every 2 semest	2.
Language of Instruction German					Pers	on respons	ible for	the M	odule		
1	Course	s of the	e Modul	le							
	Course no. Course name				Workload	(CP)	Form Teac	-	Contact Hours per Week		
	04-00-0	121-vu	Calculu	s III (civil en	gineerir	ıg)	0		Lectur Exerci		6

2 Study Content

- 1) Differential equations:
- a) First order ordinary differential equations existence and uniqueness, numerical methods;
- b) Second order ordinary differential equations linear differential equations with constant and variable coefficients, systems of linear differential equations;
- c) Partial differential equations classification, product ansatz, Fourier series;
- 2) Calculus of variations;
- 3) Probability theory conditional probabilities, random variables and distribution functions, mean and variance, central limit theorem;
- 4) Statistics:
- a) descriptive statistics;
- b) estimation techniques and confidence intervals unbiasedness and consistency, maximum likelihood estimate;
- c) statistical tests tests assuming Gaussian distribution, chi ^ 2 test of goodness of fit, analysis of variance;

3 Learning Outcomes

Im Rahmen des für ihren Studiengang Erforderlichen sollen die Studierenden über Vertrautheit mit den einfachsten Typen von Differentialgleichungen und den Anfangsgründen der Stochastik verfügen. Die Studierenden besitzen die Fähigkeit, die wichtigsten rechnerischen Methoden in ihrer Bedeutsamkeit beurteilen und auf ingenieurtechnische Fragen, insbesondere im späteren Studium und Beruf anwenden zu können. Sie besitzen Grundvoraussetzungen, sich die benötigten mathematischen Kenntnisse selbst anzueignen.

4 Requirements for Participation

gute Kenntnisse in Mathe I und II

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Written Exam, Standard)
- Module Examination (Standardkategorie (nicht mehr verwenden), Study Examination, Passed / Not Passed)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, Written Exam, Weight: 100%, Standard)

	Module Examination (Standardkategorie (nicht mehr verwenden), Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	B.Sc.BI/UI, B.Sc.MaWi: Pflichtveranstaltung, WIBI benötigen nur den Statistik-Teil
9	Literature
9	Literature wird zu Beginn der VL bekannt gegeben.
10	

Mod	lule na	me								
	Calcı	ulus III	(civil e	ngineering)						
Mod no. 04-0	lule)0-		_	Workload 180 h		f-study 90 h	Duration 1 Seme		Freque Every 2 semest	2.
Language of Instruction German Person responsible for the Module										
1	Course	es of the	e Modu	le	•					
	Course	e no.	Cours	e name			Form Teac		Contact Hours per Week	
	04-00-0)121-vu	Calculu	s III (civil engineeri	ng)	0		Lecture and Exercise		6
2	a) First method b) Seconstar c) Part 2) Calc	ds; ond ordent and vial different culus of combility ons, mea	equation ordinary er ordin ariable rential e variation theory -	differential equa ary differential ec coefficients, syste equations - classif	uations of cations	ons - linear d Tlinear differ n, product a	ifferentia rential ed nsatz, Fo	al equa quation purier s	ntions was; series;	rith

a) descriptive statistics; b) estimation techniques and confidence intervals - unbiasedness and consistency, maximum likelihood estimate; c) statistical tests - tests assuming Gaussian distribution, chi ^ 2 test of goodness of fit, analysis of variance; **Learning Outcomes** Im Rahmen des für ihren Studiengang Erforderlichen sollen die Studierenden über Vertrautheit mit den einfachsten Typen von Differentialgleichungen und den Anfangsgründen der Stochastik verfügen. Die Studierenden besitzen die Fähigkeit, die wichtigsten rechnerischen Methoden in ihrer Bedeutsamkeit beurteilen und auf ingenieurtechnische Fragen, insbesondere im späteren Studium und Beruf anwenden zu können. Sie besitzen Grundvoraussetzungen, sich die benötigten mathematischen Kenntnisse selbst anzueignen. **Requirements for Participation** gute Kenntnisse in Mathe I und II 5 Form of Examination Final Module Examination: Module Examination (Study Examination, Study Examination, Standard) Requirements on the Award of Credit Points 6 Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 100%, Standard) Usability of the Module B.Sc.BI/UI, B.Sc.MaWi: Pflichtveranstaltung, WIBI benötigen nur den Statistik-Teil Literature wird zu Beginn der VL bekannt gegeben. 10 Comment

Module Description

Module name

Mathematics I (Electrical Engineering)

Mod no. 04-0	00- 9 CP 270 h		Semester Duration 180 h			Frequency Every 2. semester				
Lan g Gerr		of Instru	action			on respons Prof. Dr. re				
1	Course	es of the	e Modu	le						
	Course no. Course name		e name		Workload	Workload (CP)		of hing	Contact Hours per Week	
	04-00-0)126-vu	Mathen Engine	natics I (Electical ering)		0		Lectur Exerci		6
2	Basics, integra		d compl us in on	ex numbers, real f e variable, vector s		-	•			
3	Learning Outcomes Die Studierenden sind vertraut mit - den elementaren Methoden der mathematischen Begriffsbildung - den elementaren Methoden des logischen Schließens Die Studierenden beherrschen die Grundzüge von - linearer Algebra - analytischer Geometrie - der Analysis von Funktionen in einer reellen Veränderlichen.									
4	Requir keine	ements	for Pa	rticipation						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
	Usually the exam is taken in form of a written test (90 min), except when there are only small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.						ne form of			
6	Requirements on the Award of Credit Points									

7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	Für B.Sc.ETiT, B.Ed.ETiT, B.Sc.WIETiT, B. Sc. Mec, B. Sc. CE, B. Sc. IST, B. Sc. MedTech
9	Literature Von Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch für Ingenieure I, Teubner, Burg, Haf, Wille: Höhere Mathematik für Ingenieure I, II, Teubner, Meyberg, Vachenauer, Höhere Mathematik 1, Springer
10	Comment

Mod	lule na	me								
	Matl	hemati	cs II (El	ectrical Enginee	ring)					
no.	4-00- 9 CP		Workload 270 h	Self-study 180 h		Duration 1 Semester		Frequency Every 2. semester		
Lan	guage (of Instru	ıction		Pers	on respons	ible for	the M	odule	
Geri	nan				Apl.	Prof. Dr. re	r. nat. St	effen l	Roch	
1	Course	es of the	e Modul	le						
	Course no. Course na		name W		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)079-vu	Mather Enginee	natics II (Electrical ering)	0		Lecture and Exercise		6	
2	Study Content Determinants, eigenvalues, quadratic forms, sequences and series of functions, Taylor and Fourier series, differentiala calculus in R^n, extrema, inverse and implicit functions, path integrals, integration in R^n									
3	Learning Outcomes • Die Studierenden besitzen ein vertieftes Verständnis mathematischer Prinzipien									
	•	Die Stu	dierend	len besitzen ein ve	rtieft	es Verständı	nis math	ematis	scher Pri	nzipieı

- Die Studierenden beherrschen die Grundzüge der Analysis von Funktionen mehrerer Veränderlichen
- Die Studierenden können die Analysis von Funktionen mehrerer Veränderlichen unter Anleitung auf Probleme der Ingenieurwissenschaften anwenden.

4 Requirements for Participation

Recommended: Mathematik I (für ET)

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc.ETiT, B.Ed.ETiT, B.Sc.WIETiT, B. Sc. Mec, B. Sc. CE, B. Sc. IST, B. Sc. MedTech

9 Literature

Von Finckenstein/Lehn/Schellhaas/Wegmann: Arbeitsbuch Mathematik für Ingenieure. Band I, Teubner Verlag,

Burg, Haf, Wille: Höhere Mathematik für Ingenieure I, II, Teubner Verlag, Meyberg, Vachenauer: Höhere Mathematik 1, Springer Verlang

10 Comment

Module Description

Module name

	Mat	thematics III (E	lectrical Enginee	ring)			
Mod no. 04-0	0-	Credit Points 9 CP	Workload 270 h	Self-study 180 h	Duration 1 Semester	Frequency Every 2. semester	
Lan ; Geri	0	of Instruction		Person respons Apl. Prof. Dr. re			
1	1 Courses of the Module						

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0127-vu	Mathematics III (Electrical Engineering)	0	Lecture and Exercise	6

2 Study Content

integral calculus: surface integrals, integral theorems; ordinary differential equations: linear and non-linear differential equations, existence and uniqueness of solutions, elementary techniques, linear systems with constant coefficients, Laplace transform; Complex Analysis: complex functions, complex differentiation, Cauchy's integral formula, power series and Laurent series, residues, residue theorem

3 Learning Outcomes

Die Studierenden erwerben die mathematischen Fähigkeiten

- zur Modellierung von ingenieurwissenschaftlichen Sachverhalten
- zur Analyse von ingenieurwissenschaftlichen Sachverhalten

Die Studierenden kennen

- grundlegende Lösungseigenschaften
- explizite Lösungsmethoden für gewöhnliche Differentialgleichungen

Die Studierenden beherrschen die Grundzüge der komplexen Funktionentheorie.

4 Requirements for Participation

Recommended: Mathematik I und Mathematik II (für ET)

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students

	taking the exam.
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc.ETiT, B.Ed.ETiT, B.Sc.WIETiT, B. C. MedTech, B.Sc.MEC, B.Sc.CE, B.Sc.IST
9	Literature Von Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch für Ingenieure II, Teubner, Burg, Haf, Wille: Höhere Mathematik für Ingenieure III, IV, Teubner Freitag, Busam: Funktionentheorie 1, Springer
10	Comment

Mod	lule na	me								
	Numerical and Statistical Methods									
Mod no. 04-0		Credit	Points 9 CP	Workload 270 h		-study 180 h	Duratio 1 Semes		Frequence Every semes	2.
Language of Instruction German Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich										
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac	- 0-	Contact Hours per Week
	04-00-0	0081-vu	Numeri Method	cal and Statistical s		0		Lectur Exerci		6
2	Study	Conten	t							
	Numerical Analysis: linear equations, interpolation, numerical integration, systems of nonlinear equations, initial value problems for ODEs, numerical methods for eigenvalue problems									

	Statistics: basic concepts of statistics and probability theory, regression, multivariate distributions, methods of estimation, confidence intervals, tests for normally distributed random variables, robust statistics
3	Learning Outcomes Fähigkeit für grundlegende Aufgabenstellungen geeignete numerische Verfahren auszuwählen und anzuwenden. Fähigkeit statistische Auswertungen vorzunehmen, grundlegende Schätzverfahren und Testverfahren durchzuführen.
4	Requirements for Participation Mathematik 1 und Mathematik 2
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Für B.Sc.ETiT, B.Sc.MEC, B.Sc.CE, B.Sc.Inf, M.Ed.Math, B.Sc.IST (PO 2007): Pflicht Für B.Sc.EPE, B.Sc.IST (bis PO 2006), B.Sc.iKT: Pflicht zusammen mit Mathematik 3 als Mathematik B
9	Literature Von Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch für Ingenieure II, Teubner Verlag Stuttgart;
10	Comment

Module name							
Mat	thematics I (Me	echanical and Pro	ocess Engineeri	ng)			
Module no. 04-00-	Credit Points 8 CP	Workload 240 h	Self-study 150 h	Duration 1 Semester	Frequency Every 2. semester		

011	4										
Lan	guage (of Instru	ıction	l	Person responsible for the Module						
	man				Prof	Dr. rer. na	t. Ulrich	Reif			
1		es of the				147 - ul-1 d	(CD)	Голи	C	Comtost	
	Course	e no.	Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)124-vu	Mathem Enginee	natics for Mechanica ering I	1	0		Lectur Exerci		6	
2	Vectors linear	naps, ei	ex num genvalu	bers, linear systen les and -vectors, so uity, differentiatio	equer	nces, series,	natrices,				
3	 Learning Outcomes Nach erfolgreichem Abschluss des Moduls können die Studierenden. • elementare Methoden der mathematischen Begriffsbildung und des logischen Schließens anwenden, • die grundlegenden Begriffsbildungen und Resultate der linearen Algebra und der analytischen Geometrie wiedergeben und anwenden, • die grundlegenden Begriffsbildungen und Resultate der Analysis einer Veränderlicher wiedergeben und anwenden, • ihre inhaltlich-logischen Beziehungen erklären, • die wichtigsten zugehörigen rechnerischen Methoden anwenden und in ihrer Bedeutsamkeit und Zuverlässigkeit beurteilen, • sich im späteren Studium und Beruf benötigte weitergehende mathematische 										
4	Requir keine	ements	for Par	rticipation							
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)										
6	Requir	ements	on the	Award of Credit	Poin	ts					
7	Grading										

	Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	 v. Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure Band I, Analysis und Lineare Algebra, 4. Aufl., Teubner, 2006. Höllig, Hörner: Aufgaben und Lösungen zur Höheren Mathematik 1, 2. Aufl., Springer, 2019. Papula: Mathematik für Ingenieure und Naturwissenschaftler Band 1 und 2, 14. Aufl., Springer Vieweg, 2014.
10	Comment

Mod	dule na	me								
	Mathematics II (Mechanical and Process Engineering)									
no.	I-00- 8 CP		Workload 240 h	Self-study 150 h		Duration 1 Semester		Frequency Every 2. semester		
	Language of InstructionPerson responsible for the ModuleGermanProf. Dr. rer. nat. Ulrich Reif									
1	Courses of the Module									
	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0)076-vu	_	natics for Mechanica ring II	1	0		Lectur Exerci		6
2										

3 **Learning Outcomes** Nach erfolgreichem Abschluss des Moduls können die Studierenden: die grundlegenden Begriffsbildungen und Resultate der Theorie der Taylor- und Fourier-Reihen wiedergeben und anwenden, die grundlegenden Begriffsbildungen und Resultate der Analysis mehrerer Veränderlicher wiedergeben und anwenden, ihre inhaltlich-logischen Beziehungen erklären, die wichtigsten zugehörigen rechnerischen Methoden anwenden und in ihrer Bedeutsamkeit und Zuverlässigkeit beurteilen, sich im späteren Studium und Beruf benötigte weitergehende mathematische Kenntnisse selbst erarbeiten. **Requirements for Participation** Mathematik 1 Form of Examination 5 Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) **Requirements on the Award of Credit Points** 6 7 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module Pflicht Literature v. Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure Band I, Analysis und Lineare Algebra, 4. Aufl., Teubner, 2006. Höllig, Hörner: Aufgaben und Lösungen zur Höheren Mathematik 2, 2. Aufl., Springer, 2019. Papula: Mathematik für Ingenieure und Naturwissenschaftler Band 1 und 2, 14.

Aufl., Springer Vieweg, 2014.

10	Comment

Mod	dule na	me									
	Mathematics III (Mechanical and Process Engineering)										
no.	-00- 4 CP		Workload	120 h	Self-study 60 h		Duration 1 Semester		Frequency Every 2. semester		
						Person responsible for the Module Prof. Dr. rer. nat. Jens Lang					
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0)125-vu	Mathem Enginee	natics for Me	chanica	1	0		Lectur Exerci		4

2 Study Content

Gewöhnliche Differenzialgleichungen: Grundlagen und elementare Lösungstechniken, exakte Differenzialgleichungen und spezielle Typen zweiter Ordnung, Lösungstheorie für Anfangswertprobleme, lineare Systeme erster Ordnung, lineare Differenzialgleichungen n-ter Ordnung, Stabilität von Differenzialgleichungen, Laplace-Transformation, lineare und nichtlineare Zweipunkt-Randwertprobleme, Sturm-Liouville-Probleme; Partielle Differenzialgleichungen: Grundbegriffe für partielle Differenzialgleichungen, partielle Differenzialgleichungen erster Ordnung, parabolische, elliptische und hyperbolische Differenzialgleichungen

3 Learning Outcomes

Nach erfolgreichem Abschluss des Moduls können die Studierenden:

- die grundlegenden Lösungseigenschaften gewöhnlicher und der einfachsten partiellen Differenzialgleichungen wiedergeben,
- ihre inhaltlich-logischen Beziehungen erklären,
- die wichtigsten Lösungsmethoden für analytisch lösbare Fälle auswählen und anwenden,
- die Lösungsmethoden in ihrer Bedeutsamkeit und Zuverlässigkeit beurteilen,
- sich im späteren Studium und Beruf benötigte weitergehende mathematische Kenntnisse selbst erarbeiten.

4	Requirements for Participation keine
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	 v. Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure Band II, 3. Aufl., Teubner, 2006. Papula: Mathematik für Ingenieure und Naturwissenschaftler Band 2, 14. Aufl., Springer Vieweg, 2015.
10	Comment

Mod	Module name										
	Numerical Analysis (Mechanical and Process Engineering)										
Module no. Credit Points 04-00- 4 CP 0117			120 h	Self-	study 60 h	Duratio 1 Semes		Frequer Every 2. semeste			
	0	of Instru	action			Person responsible for the Module					
	man					Prof. Dr. rer. nat. Jens Lang					
1	Cours	Courses of the Module									
	Course	e no.	Course	e name			Workload	(CP)	Form Teacl		Contact Hours

					per Week				
	04-00-0077-vu	Numerical Analysis	0	Lecture and Exercise	4				
2	Study Content Linear and non-linear equation systems, least-squares minimization, eigen values, interpolation, differentiation and integration, initial value problems for ODEs, difference formulas and application to boundary value problems.								
3	Learning Outcomes Fähigkeit für grundlegende Aufgabenstellungen geeignete numerische Verfahren auszuwählen und anzuwenden.								
4	Requirements for Participation Mathematik I-II								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)								
6	Requirements	on the Award of Credi	t Points						
7		Examination: e Examination (Technica :: 100%, Standard)	al Examination, o	oral / written Examinati	on,				
8	Usability of th B.Sc.MPE, B.Sc	ne Module c.AngMech: Pflicht							
9	Literature Von Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch für Ingenieure II, Teubner Verlag Stuttgart								
10	Comment								

Module name							
Matl	hematics I (for	Computer Scier	ice)				
Module	Credit Points	Workload	Self-study	Duration	Frequency		

no. 04-0	4-00-			180 h 1 Seme		Every 2. semester				
	guage o	of Instru	action			son respons . Dr. phil. na				
1	Course	es of the	e Modul	le						
	Course	e no.	Course	Course name		Workload (CP)		Forn Teac	-	Contact Hours per Week
	04-00-0)128-vu	Mathem Science	atics I (Computer)		0		Lectur Exerci		6
2	Study Content									
	 Basics: relations, functions, groups, rings, fields, complex numbers, metrics Linear algebra: vector spaces, basis, scalar products, linear maps, systems of linear equations, change of coordinates, determinants, eigenvalues, eigenvectors Analysis over R: sequences, convergence, asymptotics, series, compactness, continuity 									
3	Nach A	bstrakte	s des Me n Begrif	oduls können die s	nen, E	Beweise nac	hvollzieh	ien, Be	eweiside	een
				bstständig Beweis ıktive Vorgehensw		•	atik vers	tehen	und an	wenden,
	- die vermittelten Kenntnisse und Begriffe aus zentralen Gebieten der Mathematikgrundausbildung beherrschen, so dass sie diese für die verschiedenen Anwendungen in der Informatik nutzen können.									
	Die Stı	ıdierenc	len solle	en						
	- mit m	nathema	tischer l	Methodik und Fac	hkult	ur vertraut	sein.			
		_		pauend auf das ver e selbstständig zu			rissen Ma	athema	atik, we	itere
4	Requi ikeine	rements	for Pai	ticipation						

5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	Pflicht
9	Literature
	Skript der Veranstaltung
10	Comment

Module name											
Mathematics II (for Computer Science)											
Module no. 04-00- 0119		Credit Points 9 CP			270 h	Self-study 180 h		Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German 1 Courses of the Module					rson responsible for the Module of. Dr. phil. nat. Ulrich Kohlenbach						
	Course no.		Course name		Workload (CP)		Form Teac	-	Contact Hours per Week		
	04-00-0087-vu Mathematics II (Computer Science)		0			Lectur Exerci		6			
2	Study (Conten	t								

- Analysis over R: power series, standard functions, differential calculus and integration, Taylor Theorem, extremal values, Fourier series
- Analysis over Rn: Continuity, partial and total differentiability, extremal values, curves
- Ordinary differential equations: systems of linear ODEs, Picard-Lindelöf Theorem
- Universal algebra: algebras und subalgebras, homomorphisms, quotients

3 Learning Outcomes

Nach Abschluss des Moduls können die Studierenden:

- mit abstrakten Begriffen präzise umgehen, Beweise nachvollziehen, Beweisideen erläutern und auch selbstständig Beweise führen,
- die axiomatisch-deduktive Vorgehensweise der Mathematik verstehen und anwenden,
- die vermittelten Kenntnisse und Begriffe aus zentralen Gebieten der Mathematikgrundausbildung beherrschen, so dass sie diese für die verschiedenen Anwendungen in der Informatik nutzen können.

Die Studierenden sollen

- mit mathematischer Methodik und Fachkultur vertraut sein.
- in der Lage sein, aufbauend auf das vermittelte Grundwissen Mathematik, weitere mathematische Inhalte selbstständig zu erarbeiten.

4 Requirements for Participation

Mathematik I

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung: Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain

	proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	Literature Skript der Veranstaltung
10	Comment

Module name										
Formal Principles of Computer Science I: Automata and Formal Languages										
no. 04-0	Module no. Credit P 04-00- 0120		Points 5 CP	Points Workload 5 CP 150 h		-study 105 h	Duration 1 Semester		Frequency Every 2. semester	
					rson responsible for the Module f. Dr. rer. nat. Martin Otto					
1	Courses of the Module									
	Course no. Cours		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)091-vu		ta, Formal Languago cidability	es	0		Lectur Exerci		3
2	Study Content									
	introduction: transition systems, words, languages; basic mathematical methods and proof patterns; finite automata and regular languages; determinism and nondeterminism, closure properties and automata constructions, Kleene Theorem, Myhill-Nerode Theorem, pumping lemma; grammars and the Chomsky hierrachy, context-free languages, pumping lemma, CYK									

	algorithm; models of computation: PDA and Turing machines; decidability and recursive enumerability in the Chomsky hierarchy					
3	Learning Outcomes Die Studierenden lernen elementare Techniken und Methoden der diskreten Mathematik im Umfeld von formalen Sprachen und Automaten kennen und anzuwenden; sie lernen, endliche Automaten als Beispiel eines fundamentalen Berechnungsmodells operational und semantisch zu interpretieren und zu analysieren. Sie verfügen über die notwendigen Grundkenntnisse, Grammatiken und formalen Sprachen im Rahmen der Chomsky-Hierarchie und zugehöriger Berechnungsmodelle einzuordnen und zu analysieren.					
4	Requirements for Participation keine					
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)					
6	Requirements on the Award of Credit Points					
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)					
8	Usability of the Module Pflichtveranstaltung in Informatik-Studiengängen					
9	Literature Schöning: Theoretische Informatikkurz gefasst Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale Sprachen und Komplexitätstheorie Wegener: Theoretische Informatikeine algorithmenorientierte Einführung Skript (elektronisch unter www.mathematik.tu-darmstadt.de#47; ~otto)					
10	Comment					

Mod	dule na	me								
Module		-	of Computer Scie Workload 150 h		E-study Duratio 105 h 1 Semes		on Freque		ency 2.	
	guage o	of Instru	ıction			son respons			odule	
1	Course	es of the		le e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0	0090-vu	Proposi Predica	tional Logic and te Logic		0		Lectur Exerci		3
	function complete syntax structu Herbra sequent undeci	nal comete proof and sen res and nd theo t calcult dability	ipletene f calculi nantics assignn rem, co us, Gödo of first-	of propositional loss and normal form: resolution and a of first-order logic, nents, normal form mpactness, completel's Completeness forder logic; on expressiveness a	ns, c sequ ns, Sl ete pr Theo	ent calculus kolemization roof calculi: rem;	; (ground) resol	lution a	nd a
3	Learning Outcomes Die Studierenden werden mit Inhalten und Methoden der mathematischen Logik und ihrer Rolle in der Informatik vertraut gemacht. Sie lernen die grundlegenden Begriffe und Resultate der Logik, insbesondere der Logik erster Stufe, kennen und anzuwenden. Sie beherrschen die grundsätzlichen mathematischen Methoden in der Behandlung von Syntax, Semantik und formalen Beweisen, sowie die Diskussion einfacher modelltheoretischer und algorithmischer Aspekte der behandelten logischen Systeme									
4	_			rticipation neinbildung und Fo	orma	le Grundlage	en I			
5		of Exam Module I Modul Standa	Examina e Exam		Exai	mination, ora	al / writt	ten Ex	aminatio	on,

6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflichtveranstaltung in Informatikstudiengängen
9	Literature Burris: Logic for Mathematics and Computer Science Schöning: Logik für Informatiker Boolos, Burgess, Jeffrey: Computability and Logic Skript (2 Teile, elektronisch unter www.mathematik.tu-darmstadt.de#47;~otto)
10	Comment

Mod	lule name	:							
	Project	in Mathem	atics						
Module		r edit Points 6 CP	Workload 180 h	154.28572082		Duration 1 Semester		Frequency Every semester	
Language of Instruction German and English				Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Courses of	of the Modul	le						
	Course no	o. Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0094-pj Project for Computational Engineering			0		Projec	t	0	
	04-10-0358-se Seminar in Mathematics (nu Bachelor		ım),	n), 0		Seminar		2	
	04-10-035	9-se Seminar Bachelo	r in Mathematics (nu r	ım),	0		Semin	ar	2
	04-10-036	0-se Seminar	r in Mathematics (op	ot),	0		Semin	ar	2

		Docholon		ĺ	1					
		Bachelor	1	l						
	04-10-0361-se	Seminar in Mathematics (opt), Bachelor	0	Seminar	2					
	04-10-0362-se	Seminar in Mathematics (sto), Bachelor	0	Seminar	2					
	04-10-0363-se	Seminar in Mathematics (sto), Bachelor	0	Seminar	2					
2	Study Conten interdisciplina	t ry project with changing topic	s							
3	Learning Outcomes Lösungsstrategien für konkrete Problemstellungen entwickeln, erlernen von Projektmanagement: Gliederung in Teilschritte, Formulierung von Zwischenzielen, Aufteilung von Aufgaben an die Team-Mitglieder, Auswahl geeigneter Präsentationstechniken, je nach Thema auch experimentelles Arbeiten und die Fähigkeit, geeignete Software anzuwenden.									
4	_	s for Participation dule und Wahlveranstaltunger	n aus der Mathematil	ζ						
5	Form of Exam Final Module I • Modul Passed	Examination: le Examination (Study Examin	ation, Study Examin	ation, Passed	/ Not					
6	Requirements	s on the Award of Credit Poir	nts							
7		Examination: le Examination (Study Examin / Not Passed)	ation, Study Examin	ation, Weight:	100%,					
8	Usability of th Wahlpflichtmo	ne Module odul. Kann als Ausgangspunkt	einer Bachelorarbeit	dienen.						
9	Literature wird je nach T	hema spezifiziert								
10	Comment Verantwortlich	n: Studiendekan								

Module name Mathematics I Module Frequency Credit Points | Workload Self-study **Duration** no. Every 2. 04-00-7 CP 210 h 135 h 1 Semester semester 0125/f **Language of Instruction** Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch German **Courses of the Module** Course no. Course name Workload (CP) Form of Contact Teaching Hours per Week 04-00-0118-vu | Mathematics I 5 0 Lecture and Exercise

2 **Study Content**

Fundamentals: numbers and vectors, equations and inequalities, elementary geometry, convergence of sequences, elementary functions; differential calculus of one variable: continuity and differentiability, intermediate value and mean value theorems, extremal problems, inverse functions; integral calculus of one variable: fundamental theorem of calculus, rules of integration, improper integrals, approximation techniques; Linear Algebra: matrices, systems linear equation; Stochastics: combinatorics, binomial-, Poisson-and normal distributions

3 **Learning Outcomes**

Nach Abschluss des Moduls können die Studierenden

- die grundlegenden Begriffsbildungen und Resultate der Vektorrechnung und der Linearen Algebra wiedergeben und anwenden,
- die grundlegenden Begriffsbildungen und Resultate der Analysis von Funktionen einer Veränderlichen wiedergeben und die wichtigsten zugehörigen rechnerischen Methoden anwenden,
- erste elementare Ergebnisse der Stochastik wiedergeben und anwenden,

Die Studierenden sollen

- Kenntnisse über die wechselseitigen Beziehungen der Vektorrechnung und Linearen Algebra und ihre geometrische Bedeutung erwerben,

	 die Rolle der Analysis in den Natur- und Ingenieurwissenschaften erkennen, die Bedeutsamkeit und Zuverlässigkeit der erlernten Rechenmethoden beurteilen können,
	- die Grundvoraussetzungen erwerben, um sich im späteren Studium und Beruf benötigte weitergehende mathematische Kenntnisse selbst erarbeiten zu können.
4	Requirements for Participation keine
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module JBA, B.Sc. Sportwissenschaft und Informatik, B.Ed.Metall: Pflicht
9	Literature
10	Comment

Module na	Module name											
Mat	Mathematics I											
Module no. 04-00- 0125/s	Credit Points 7 CP	Workload 210 h	Self-study 135 h	Duration 1 Semester	Frequency Every 2. semester							
Language German	of Instruction		Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch									

1	Courses of the Module							
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-00-0118-vu	Mathematics I	0	Lecture and Exercise	5			

2 Study Content

Fundamentals: numbers and vectors, equations and inequalities, elementary geometry, convergence of sequences, elementary functions; differential calculus of one variable: continuity and differentiability, intermediate value and mean value theorems, extremal problems, inverse functions; integral calculus of one variable: fundamental theorem of calculus, rules of integration, improper integrals, approximation techniques; Linear Algebra: matrices, systems linear equation; Stochastics: combinatorics, binomial-, Poisson-and normal distributions

3 Learning Outcomes

Nach Abschluss des Moduls können die Studierenden

- die grundlegenden Begriffsbildungen und Resultate der Vektorrechnung und der Linearen Algebra wiedergeben und anwenden,
- die grundlegenden Begriffsbildungen und Resultate der Analysis von Funktionen einer Veränderlichen wiedergeben und die wichtigsten zugehörigen rechnerischen Methoden anwenden,
- erste elementare Ergebnisse der Stochastik wiedergeben und anwenden,

Die Studierenden sollen

- Kenntnisse über die wechselseitigen Beziehungen der Vektorrechnung und Linearen Algebra und ihre geometrische Bedeutung erwerben,
- die Rolle der Analysis in den Natur- und Ingenieurwissenschaften erkennen,
- die Bedeutsamkeit und Zuverlässigkeit der erlernten Rechenmethoden beurteilen können,
- die Grundvoraussetzungen erwerben, um sich im späteren Studium und Beruf benötigte weitergehende mathematische Kenntnisse selbst erarbeiten zu können.

4 Requirements for Participation keine

5 Form of Examination

	Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module JBA, B.Sc. Sportwissenschaft und Informatik, B.Ed.Metall: Pflicht
9	Literature
10	Comment

Mod	lule na	me									
Mathematics II											
Module no. Credit 04-00- 0126		Points 4 CP	Workload 12	20 h	Self-	- study 75 h	Duratio 1 Semes		Frequency Every 2. semester		
	Language of Instruction German						on respons . Dr. rer. nat				
1	Course	es of the	e Modul	le							
	Course no. Cours		Course	e name		Workload (CP)		Form Teac		Contact Hours per Week	
	04-00-0	0070-vu	Mathem	natics II			0 Lectur Exerci				3
2	Study Content Linear Algebra: linear mappings, determinants, complex numbers, eigenvalues; power series, Fourier series; differential calculus: curves, scalar and vector fields, partial derivatives, totally differentiable functions, implicit function theorem, optimization with constraints; ordinary differential equations: separation of variables, linear ODEs, systems of linear ODEs with constant										

	coefficients; integral calculus: path integrals, potential, computation of volumes, coordinate transformations
3	Learning Outcomes Nach Abschluss des Moduls können die Studierenden
	- ein vertieftes Verständnis der grundlegenden Begriffe) der Linearen Algebra vorweisen,
	- Die Grundzüge der Analysis von Funktionen mehrerer Veränderlichen wiedergeben und die wichtigsten zugehörigen rechnerischen Methoden anwenden,
	- die einfachsten Typen von gewöhnlichen Differentialgleichungen erkennen und lösen.
	Die Studierenden sollen
	- die Rolle der Analysis in den Natur- und Ingenieurwissenschaften erkennen,
	- die Bedeutsamkeit und Zuverlässigkeit der erlernten Rechenmethoden beurteilen können,
	- die Grundvoraussetzungen erwerben, um sich im späteren Studium und Beruf benötigte weitergehende mathematische Kenntnisse selbst erarbeiten zu können.
4	Requirements for Participation keine
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Ed.Metall und B.Sc. Sportwissenschaften und Informatik: Pflicht
9	Literature

10	Comment

Мо	dule na	me								
	Line	ar Alge	bra (fo	r Physicists)						
		Points 8 CP	Workload 240 h	Self	f- study 150 h	Duration 2 Semester		Frequency Every 2. semester		
	iguage o	of Instru	uction			son respons f. Dr. rer. nat				ſ
1	Course	es of the	e Modu	le						
	Course no.		Cours	е пате		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0	0067-vu	and Tea	Algebra II (for Physion Siching Degrees Matics))	es	0		Lecture and Exercise		3
	04-00-0	04-00-0117-vu Linear Algebra I (for Physiand Teaching Degrees (Mathematics))		aching Degrees	os 0			Lecture and Exercise		3
	equation	ons, eige	envalues	nappings, matrices s, orthogonal and n quadratic forms, d	unita	ry transform	ations, s	ymme	tric her	
3	Learning Outcomes Die Studierenden kennen Konzepte, Begriffe und Methoden der Linearen Algebra, insbesondere analytische Geometrie, Vektorräume und lineare Abbildungen, Matrizen, Eigenwerte und Orthogonalisierung. Sie sind befähigt, mathematische Lösungsstrategien im Hinblick auf die genannten Themenfelder mit den erlernten Methoden anzuwenden, mathematische Beweise nachzuvollziehen und in einfachen Fällen zu führen.									
4	Requi ikeine	rements	for Pa	rticipation						
5		of Exam Module I Modul Standa	Examina e Exam		Exai	mination, ora	al / writt	ten Ex	aminatio	on,

Fachprüfung: Usually the exam is taken in form of a written test (120 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Bestehen der Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 8 **Usability of the Module Bachelor Physics** 9 Literature K. Jänich: Lineare Algebra G.Fischer: Lineare Algebra P. Halmos: Finite-dimensional vector spaces Comment 10

Mod	Module name										
	Mathematics and Statistics for Biologists										
Module no. 04-00- 0128		Credit	Points 6 CP	Workload 180 h			Duration 1 Semester		Freque Every 2 semeste		
Lan Geri		of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Volker Martin Betz						
1	Course	es of the	e Modul	le							
	Course no. Course name		e name	Workload		(CP)	Form of Teaching		Contact Hours per Week		
	04-00-0)119-vu	Mathem	natics and Statistics	for	0		Lectur	e and	5	

	Biologists Exercise									
2	Study Content									
	sets and operations with sets, sequences and infinite series, basics of differential and integral calculus; statistical measurements, calculus of regression, estimating densities; probability measures, random variables and distributions, expectation and variance, independence of random variables, law of large numbers and central limit theorem; point estimators and domain esstimators; statistical tests, single factor variance analysis									
3	Learning Outcomes									
	Die Studierenden werden mit einigen grundlegenden Konzepten aus der Mathematik vertraut gemacht und erwerben darauf aufbauend grundlegende Kenntnisse über ausgewählte Bereiche der Statistik, insbesondere im Zusammenhang mit Punktschätzverfahren, Bereichsschätzverfahren und statistischen Tests. Ziel dabei ist einerseits, den Studierenden ein für die richtige Anwendung und Interpretation (der Resultate) von statistischen Verfahren entscheidendes Verständnis für die mathematische Modellierung des Zufalls und darauf aufbauender statistischer Schlussweisen zu vermitteln, und anderseits eine Reihe von statistischen Verfahren mit Anwendbarkeit bei biologischen Fragestellungen (wie z. B. die einfaktorielle Varianzanalyse) vorzustellen.									
4	Requirements for Participation Mathematik I									
5	Form of Examination Final Module Examination:									
	Module Examination (Technical Examination, oral / written Examination, Standard)									
	Module Examination (Study Examination, Study Examination, Passed / Not Passed)									
6	Requirements on the Award of Credit Points									
7	Grading Final Module Examination:									
	 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 									
	 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) 									
8	Usability of the Module Pflicht									

Literature

 Freedman, Pisani, Purves: Statistics. Notron, 1998 Fahrmeir, Künstler, Pigeot, Tutz: Statistik. Der Weg zur Datenanalyse. Springer, 2001 Quinn, Keough: Experimental Design and Data Analysis for Biologists. Cambridge, 2007

 Comment

 Verantwortlich: Herr Betz (sto)

Mo	dule	500311	<u> </u>	nomical Enginee						
no. 04-00- 0129		Credit Points 4 CP		Workload	Self	-study	Duratio	on	Frequ	•
				120 h	•		1 Semester		Every 2. semester	
	guage (man	of Instru	action		Pers	son respons	ible for	the M	odule	
1	Course	es of the	e Modul	le						
			e name		Workload	(CP)	Forn Teac	_	Contact Hours per Week	
	04-00-0)129-vu	Statistic	es I	0			Lecture and Exercise		3
2	Study Content descriptive statistics (collecting and representing data, histogram); theory of probability (random variables, combinatorics, distribution and their moments); estimators (samples, central limit theorem. point and interval estimators); testing (hypothesis testing, significance, error of the first and second kind, chi-square test, distribution testing)									
_	descrip of prob momen estima	oability (nts); est tors); te	(randon) imators sting (h	n variables, combin (samples, central ypothesis testing,	nator limit signif	ics, distribut theorem. po ficance, erro	ion and int and	their interva	al	

5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	Literature Bamberg, G., Bauer, F., Krapp, M.: Statistik, 13. Aufl., Oldenbourg, München, 2007 Fahrmeir, L., Künstler, R., Pigeot, I. Tutz, G.: Statistik -Der Weg zur Datenanalyse. 4. Aufl., Springer, Berlin 2003 Schira, J., Statistische Methoden der VWL und BWL: Theorie und Praxis, 2. Aufl., München usw., Pearson Studium, 2005
10	Comment

Mod	Module name											
	Didactical seminar for teachers											
Module no. Cr 04-00- 0135		Credit	Points 3 CP	Workload 90 h		Self-study 60 h Duration 1 Semes			Fvery 2			
Lan g Geri	guage o nan	f Instru	ıction			Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
1	Course	s of the	e Modul	le								
	Course no. Course name			Workload	(CP)	Form Teac	_	Contact Hours per Week				
	04-00-0039-se Seminar for subject-specific didactics: Algebra in school				0		Semin	ar	2			
	04-00-0	109-se	Seminar	for subject-specific		0		Semin	ar	2		

		1:1 :: 0 1: . 1 . : :		<u> </u>				
	04-00-0112-se	didactics: Online task training Seminar for subject-specific	0	Seminar	2			
	04-00-0112-30	didactics: Mathematical modeling with students		Schillar	2			
	04-00-0159-se	Seminar for subject-specific didactics: Analysis in schools	0	Seminar	2			
	04-00-0160-se	Seminar for subject-specific didactics: Stochastics in schools	0	Seminar	2			
	04-00-0249-se	Seminar for subject-specific didactics: New media in mathematical lessons	0	Seminar	2			
	04-00-0290-se	Seminar for subject-specific didactics: Didactics of Probability	0	Seminar	2			
	04-00-0291-se	Seminar for subject-specific didactics: Long-term competence development	0	Seminar	2			
	04-10-0533-se	Didactics of Geometry	0	Seminar	2			
2	Study Conten siehe Teilmodi							
3	Learning Outcomes siehe Teilmodule							
4	Requirements for Participation Pflichtmodul "Grundlagen des Lehrens und Lernens von Mathematik" abgeschlossen							
5	Form of Exam Final Module I		mination oral/wri	tten Examina	tion			
	Standa	· · · · · · · · · · · · · · · · · · ·	illiliacion, orar / wir	eteli Ezullilla	,			
6	Requirements	on the Award of Credit Poin	its					
7	Grading Final Module I	Examination:						
		e Examination (Technical Examination (1997) et al. 1998, Standard)	mination, oral / wri	tten Examina	tion,			
8	Usability of th Fachdidaktisch	ne Module nes Seminar im Wahlpflichtber	eich, K-Modul					
9	Literature siehe Teilmod	ule						
10	Comment							

Mo	dule na	me								
	Sem	inar in	Mathe	matics (alg), Mas	ter					
Module no. Credit Point 04-00- 6 C C C C C C C C C C C C C C C C C C		Points 6 CP	Workload 180 h	Self-study 150 h		Duration 1 Semester		Frequency Every semester		
	Language of Instruction German and English					son respons liendekan*ii				
1	Course	es of the	e Modu	le				_		
	Course no. C		Cours	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-00-0)203-se	Semina: Master	r in Mathematics (al	g),	0		Semin	ar	2
3	Learni Die Stu Sachve und pr	ng Outo idierend erhalte a äsentier	comes len kön neigner en, sow	ra, Geometry, Funnen sich eigenstän und in einem ansie gegebenfalls sch	dig a sprech	nspruchsvol henden Fach ch dokumen	vortrag tieren.	erläut	ern	
4	_			rticipation ch Angabe						
5		of Examine Examine [04-00	nation:	se] (Study Examina	ation	, Presentatio	on, Passe	ed / N	ot Passe	d)
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradir Course	n g Examir	nation:							

	• [04-00-0203-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	Vertiefungsbereich (Studienleistung)
9	Literature Wird je nach Thema angegeben. Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag? www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag
10	Comment Verantwortlich: Studiendekan

Mod	Module name										
	Seminar in Mathematics (ana), Master										
Module no. Cred 04-00- 0140		Credit	Points 6 CP	Workload 180 h		f- study 150 h	Duratio 1 Seme		Frequency Every semester		
	guage o			son respons diendekan*ii							
1				e name		Workload (C		Form of Teaching		Contact Hours per Week	
	04-00-0)204-se	Semina: Master	r in Mathematics (ar	na),	0		Seminar		2	
2		Content topics of	t of analys	sis				1			
3	Learning Outcomes Die Studierenden können sich eigenständig anspruchsvolle mathematische Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern und präsentieren, sowie gegebenfalls schriftlich dokumentieren. Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages, führen.										
4	_			cticipation ch Angabe							

5	Form of Examination
	Course Examination:
	• [04-00-0204-se] (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading
	Course Examination:
	• [04-00-0204-se] (Study Examination, Study Examination, Weight: 100%, Passed
	/ Not Passed)
8	Usability of the Module
	Vertiefungsbereich (Studienleistung)
9	Literature
	Wird je nach Thema angegeben.
	Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag?
	www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag
10	Comment
	Verantwortlich: Studiendekan

Mod	Module name										
	Seminar in Mathematics (geo), Master										
Module no. 04-00- 0141		Credit	Points 6 CP			-study 150 h	y Duration 150 h 1 Semest		1. 1.		
						Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Course	s of the	e Modul	le				_		_	
	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per Week			
	04-00-0205-se Seminar in Mathematics (geo Master			eo),	, 0		Semin	ıar	2		
2	Study Content special topics of geometry and approximation										

3	Learning Outcomes
	Die Studierenden können sich eigenständig anspruchsvolle mathematische
	Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern
	und präsentieren, sowie gegebenfalls schriftlich dokumentieren.
	Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages,
	führen.
	Tunien.
4	Requirements for Participation
	Vertiefungsmodule nach Angabe
5	Form of Examination
	Course Examination:
	• [04-00-0205-se] (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading
	Course Examination:
	• [04-00-0205-se] (Study Examination, Study Examination, Weight: 100%, Passed
	/ Not Passed)
	, 1.011 associ
8	Usability of the Module
	Vertiefungsbereich (Studienleistung)
9	Literature
	Wird je nach Thema angegeben.
	Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag?
	www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag
10	Comment
10	Verantwortlich: Studiendekan
	verantworthen: Studiendekan

Mod	Module name									
Seminar in Mathematics (log), Master										
Module no. Credit Points Workload Self-study Duration Frequency										
04-0 014		6 CP	180 h	150 h	1 Semester	Every semester				
Lan	guage	of Instruction		Person respons	ible for the M	Todule				
Gen	man an	nd English		Studiendekan*in des Fachbereichs 04						
1 Courses of the Module										

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week							
	04-00-0206-se	Seminar in Mathematics (log), Master	0	Seminar	2							
2	Study Contents special topics of											
3	Learning Outcomes Die Studierenden können sich eigenständig anspruchsvolle mathematische Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern und präsentieren, sowie gegebenfalls schriftlich dokumentieren. Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages, führen.											
4	-	Requirements for Participation Vertiefungsmodule nach Angabe										
5	Course Examir • [04-00	Form of Examination Course Examination: • [04-00-0206-se] (Study Examination, Study Examination, Passed / Not Passed)										
6	Requirements	on the Award of Credit Poin	ts									
7	Grading Course Examin [04-00 / Not P	0-0206-se] (Study Examination	, Study Examination	, Weight: 100%	%, Passed							
8	Usability of th Vertiefungsber	ne Module reich (Studienleistung)										
9	Zusätzlich: Ma	Literature Wird je nach Thema angegeben. Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag? www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag										
10	Comment Verantwortlich	ı: Studiendekan										

Mod	dule na	me									
	Semi	inar in	Mathe	matics (num), Ma	aste	r)					
Mod no. 04-0	00-	Credit	Points 6 CP	Workload 180 h	Self	-study 150 h	Duratio 1 Seme	_	Freque Every	ency semester	
Lan						Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Course	es of the	e Modu	le							
			e name		Workload (CP)		Form Teac		Contact Hours per Week		
	04-00-0207-se Seminar in Mathematics Master				ım),	0		Semin	ar	2	
2	Study Content special topics of numerical analysis and scientific computing										
3	Die Stu Sachve und pra	rhalte a äsentier inen ein	len kön neigner en, sow	nen sich eigenstän und in einem ans ie gegebenfalls sch Diskussion über In	prec riftli	henden Fach ich dokumen	ivortrag itieren.	erläut	ern		
4	_			rticipation ch Angabe							
5		of Examir Examir [04-00	nation:	e] (Study Examina	ation	, Study Exar	mination	ı, Pass	ed / No	ot Passed)	
6	Requir	ements	on the	Award of Credit	Poin	ts					
7	Gradin Course	Examir)-0207-s	e] (Study Examina	ation	., Study Exar	nination	ı, Weig	ht: 100	%, Passed	
8	Usabil	ity of th	ie Modi	ıle							

	Vertiefungsbereich (Studienleistung)							
9	Literature Wird je nach Thema angegeben. Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag? www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag							
10	Comment Verantwortlich: Studiendekan							

Mod	lule na		_							
Mod		inar in	Mathe	matics(opt), Mas	ter					
no.	auic	Credit	Points	Workload	Self	-study	Duratio	n	Frequ	ency
04-0 014			6 CP	180 h		150 h	1 Seme	ster	Every	semester
		of Inetri	ıction		Dore	son respons	ible for	tha M	odule	
	Language of Instruction German and English					diendekan*ii				
1	l		e Modu	le	ļ					
	Course no. Cour			e name			Workload (CP)		n of hing	Contact Hours per Week
	04-00-0)208-se	Semina: Master	r in Mathematics (o _l	ematics (opt), 0			Seminar		2
2		Conten topics o	t of optim	ization						
3	Die Stu Sachve und pro Sie kör	Learning Outcomes Die Studierenden können sich eigenständig anspruchsvolle mathematische Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern und präsentieren, sowie gegebenfalls schriftlich dokumentieren. Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages, führen.								
4	_	Requirements for Participation Vertiefungsmodule nach Angabe								
5	_	of Exam Examin	nination nation:	ı						
	•	[04-00)-0208-s	e] (Study Examina	ation	, Study Exar	nination	, Pass	ed / No	ot Passed)

6	Requirements on the Award of Credit Points
7	Grading
	Course Examination:
	• [04-00-0208-se] (Study Examination, Study Examination, Weight: 100%, Passed
	/ Not Passed)
8	Usability of the Module
	Vertiefungsbereich (Studienleistung)
9	Literature
	Wird je nach Thema angegeben.
	Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag?
	www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag
10	Comment
	Verantwortlich: Studiendekan

Mod	dule na	me								
	Sem	inar in	Mathe	matics (sto), Mas	ter					
Mod no. 04-0	dule 00-	Credit Points 6 CP		Workload 180 h		- study 150 h	Duration 1 Semester		Frequency Every semester	
014	5									
Language of Instruction German and English					s <mark>on respons</mark> liendekan*ii					
1	Courses of the Module									
	Course no. Course name					Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0	0209-se	Seminar in Mathematics (sto Master			0, 0			ıar	2
2	Study Content special topics of stochastics									
3	Learni	ng Out	comes							
				nen sich eigenstän	_	-				
			•	und in einem ans	-		•	erläut	ern	
	und pr	äsentier	en, sow	ie gegebenfalls sch	ıriftli	ch dokumen	itieren.			

	Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages, führen.
4	Requirements for Participation Vertiefungsmodule nach Angabe
5	Form of Examination Course Examination: • [04-00-0209-se] (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading Course Examination: • [04-00-0209-se] (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)
8	Usability of the Module Vertiefungsbereich (Studienleistung)
9	Literature Wird je nach Thema angegeben. Zusätzlich: Manfred Lehn: Wie halte ich einen Seminarvortrag? www.mathematik.uni-mainz.de/Members/lehn/le/seminarvortrag
10	Comment Verantwortlich: Studiendekan

Mod	dule na	me									
	Alge	braic N	umber	Theory							
Mod no. 04-0		Credit	Points 9 CP	Workload	270 h		study 180 h	Duratio 1 Semes		Frequent Every 2 semeste	•
	guage man	of Instru	ıction				on respons Dr. rer. na				dhorn
1	Cours	es of the	e Modul	le							
Course no. Course nam		e name		Workload		(CP) Form		_	Contact Hours per Week		

	04-00-0181-vu Algebraic Number Theory		Lecture and Exercise	6								
2	Study Content Dedekind domains, prime ideal decomposition Dirichlet unit theorem, extension of Dedekind global and local fields, adels, idels.		on,									
3	Learning Outcomes The students acquire basic techniques and kno Algebraic Number Theory of number fields and They are able to answer typical questions.	· ·										
4	Requirements for Participation Algebra	llgebra										
5	Form of Examination Final Module Examination: • Module Examination (Technical Exam Standard)	ination, oral / writt	en Examinatio	on,								
6	Requirements on the Award of Credit Points	S										
7	 Grading Final Module Examination: Module Examination (Technical Exam Weight: 100%, Standard) 	ination, oral / writt	en Examinatio	on,								
8	Usability of the Module Für B.Sc.Math, B.Sc.Math (bilingual), B.Sc.MC Wahlpflichtbereich Für M.Sc.Math, Vertiefungsbereich, M.Sc.WiM											
9	Literature (1) J. Neukirch: Algebraic Number Theory, Sp. (2) S. Lang: Algebraic Number Theory, Addiso (3) J.S. Milne: Algebraic Number Theory, cour (4) D. Zagier: Zetafunktionen und Quadratisch (5) J. Cassels, A. Fröhlich: Algebraic Number T	n-Wesley se notes ne Zahlkörper, Sprir	nger									
10	Comment											

	Parti	al Diffe	rential	Equations II						
Module no. 04-00- 0153				Workload 270 h	Self	F- study 180 h	Duration 1 Semester		Frequency Every 2. semester	
	guage o man	of Instru	ıction			son respons f. Dr. rer. nat				
1	Courses of the Module									
			Course	e name		Workload (CP)		Forn Teac		Contact Hours per Week
	04-00-0	065-vu	Partial I	Differential Equation	ıs II	0		Lectui Exerci		6
	The ori		n of the	oplications, for exa lecture is shaped l	_					
3	- are the different them, - they requation they be solution problem.	nt fields master rons and know es n theory ns of pa	nts fami of appl nodern can app sential p of part artial dif	liar with current pication (e.g. fluid single) functional analytically them to simple properties of Sobolial differential equations analytical methods	mecheal m conc lev sp nation	nanics, mater methods for the crete problem paces and are ns. Introduce m different f	rial scierne studyns, e able to tion to riields of a	of par of expla noderi	nd can tial diff in their n metho	explain erential role in the
4	Requirements for Participation je nach Schwerpunktsetzung: Modul Partielle Differentialgleichungen I, oder Modul Funktionalanalysis + Modul Partielle Differentialgleichungen: klassische Methoden.									
5		of Exam Iodule E Modul Standa	Examina e Exami		Exai	mination, ora	al / writ	ten Ex	aminati	on,

6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Consolidation M.Sc.Math.
9	Literature Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order Amann: Linear and Quasilinear Parabolic Problems Dafermos: Hyperbolic Conservation Laws in Continuum Physics Galdi: An Indroduction to Mathematical Theory of the Navier-Stokes Equations
10	Comment

Mo	dule na	me									
	Mat	hemati	cal Stat	tistics							
Module no. Credi 04-00- 0199		Credit	Points 9 CP	Workload 270 h	Self	-study 180 h	Duration 1 Semester		Frequency Every 4. semester		
	Language of Instruction German					on respons Dr. rer. na					
1	Course	Courses of the Module									
	Course no. Cours			e name		Workload (CP) Form of Teachi			Contact Hours per Week		
	04-00-0073-vu Mathematical Statistics						Lectui Exerci		6		
2	Estima	Study Content Estimation of distributions, VC theory, density estimation, point estimation, statistical tests, confidence intervals, nonparametric regression.									
3	The st		know ar	nd understand the them. They have a			-	-		-	

and are able to learn new knowledge in this field by themselves. Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly. **Requirements for Participation** recommended: Probability theory 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 6 **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module M.Sc.Math, M.Sc.WiMa: Vertiefungsmodul in Stochastik Literature Witting: Mathematische Statistik I 10 Comment

Module name									
Algebraic Geometry									
Module no. 04-00- 0222	Credit Points 9 CP	Workload 270 h	Self-study 180 h	Duration 1 Semester	Frequency Every 2. semester				
Language	of Instruction		Person responsible for the Module						

Ger	man		Prof. Dr. rer. nat. Nils S	Scheithauer							
1	Courses of the	e Module									
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week						
	04-00-0221-vu	Algebraic Geometry	0	Lecture and Exercise	6						
2	Study Conten Affine varieties singular points	s, projective varieties, mo	rphisms, rational maps, s	smooth and							
3	varieties and s	The students understand the concepts of affine and projective varieties, maps between varieties and singular points. They have basic knowledge in the theory of curves. They are able to solve geometric problems with the presented methods.									
4	Requirements for Participation Algebra										
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)										
6	Requirements	on the Award of Credit	Points								
7		Examination: le Examination (Technical :: 100%, Standard)	Examination, oral / wr	itten Examinat	ion,						
8		., B.Sc.Math.(bilingual), B reich Für M.Sc.Math: Vert									
9	Literature K. Hulek, Elementary algebraic geometry, AMS R. Hartshorne: Algebraic geometry, Springer I. R. Shafarevich: Basic algebraic geometry 1,2										
10	Comment										

Modul no. 04-00- 0233 Langu Germa 1 Co	courses of the Course no.	Points 9 CP uction e Modul Course	Workload 270 h	Pers	-study 180 h son respons . Dr. rer. nat	. Martin	the M	Freque Every 2 semeste odule	2.
Germa 1	Courses of the Course no.	e Modul Course			Dr. rer. nat	. Martin		odule	
0-4 0-2 2 St	Course no. 4-00-0090-vu	Course			Workload	(CP)			
0 ² 0 ² 2 St	4-00-0090-vu	Proposit	e name		Workload	(CP)			
0 ² 2 St						(01)	Form Teac	_	Contact Hours per Week
2 St	4-00-0091-vu	ricuical	tional Logic and te Logic	0		Lecture and Exercise		3	
-			ta, Formal Language idability	es	0		Lecture and Exercise		3
ar pr fir co ur	nd recursive propositional list-order logi ompactness t indecidability	enumera logic: co lc: struct heorem, of first-	mpactness, completures and assignment proof calculi, Göd order logic;	ete p ents, lel's o	roof calculi; Skolemisatio completeness	on, Herb s theorei	rand T	Theorem	,
Di Be de in di Be de de	undecidability of first-order logic; optional: digressions on expressiveness and model checking Learning Outcomes Die Studierenden können die einschlägigen Begriffe, Methoden und Beweistechniken aus diskreter Mathematik und Logik im Zusammenhang der mathematischen Grundlagen der theoretischen Informatik interpretieren, einordnen und anwenden. Insbesondere beherrschen sie die Grundlagen der Analyse formaler Sprachen und abstrakter Berechnungsmodelle. Sie können die Grundbegriffe der mathematischen Logik anhand typischer Fragestellungen der theoretischen Informatik erläutern, auf Beispiele anwenden, algorithmische Methoden diskutieren und deren Grenzen anhand einschlägiger Sätze illustrieren.								

5	Form of Examination
3	
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Standard)
	Standard)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	Wahlpflicht im Bachelorstudiengang Mathematik
9	Literature
	Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale
	Sprachen und Komplexitätstheorie
	Schöning: Theoretische Informatik – kurz gefasst
	Boolos, Burgess, Jeffrey: Computability and Logic
	Burris: Logic for Mathematics and Computer Science
	Skripte (elektronisch unter www.mathematik.tu-darmstadt.de/~otto)
10	Comment

Mod	Module name									
International Internet Seminar										
Module no. 04-00- 0239		Credit	Points 9 CP	Workload 270		Self-study Duration 180 h 1 Semest			Frequency Irregular	
Language of Instruction English Dr. rer. nat. Robert H Courses of the Module									odule	
•	Course no. Course name				Workload	(CP)	Form Teac	-	Contact Hours per Week	
	04-00-0237-vu International Internet Sen		Internat	ional Internet Ser	ninar	0		Lectur Exerci	-	6

2 Study Content

Based on knowledge from functional analysis a topic from the field of evolution equations, relevant for actual research, is introduced. Possible topics are and were among others: semigroup theory, heat kernels, form methods, control theory, gradient systems, stochastic partial differential equations, regularity theory, ergodic theory, positive operators,

3 Learning Outcomes

Students learn to

- state and explain the essential analytic theorems and methods covered by the course
- apply these methods to specific partial differential equations and solve the corresponding problems
- assess the scope of the results of the course
- develop methods to independently work with mathematical texts

4 Requirements for Participation

recommended: Functional Analysis

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

lecture notes

10 Comment

recommended: Mathematics: Master (ana)

Mod	lule na		ررا ممالين	CF							
Mod		ticai Sti	udies in	I CE							
no.	luic	Credit	Points	Workload	Self	-study	Duratio	Ouration		Frequency	
04-0			4 CP	120 h		90 h	1 Semester		Every 2 semeste		
0267											
Lan g Gerr		of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Jan Giesselmann						
1	Course	es of the	e Modul	le							
	Course no. Course name		Workload (CP)		Form of Teaching		Contact Hours per Week				
	04-00-0	264-pr	Practica	l Studies in CE		0		Projec	t	2	
2	Study Content										
3	3 Learning Outcomes										
4	Requir	ements	for Pai	rticipation							
5			nination								
	Final M	Iodule I	Examina	ition:							
	•	Modul Not Pas		ination (Study Exa	mina	ation, oral /	written I	Examii	nation, l	Passed /	
6	Requir	ements	on the	Award of Credit	Poin	ts					
7	Gradin	•	Examina								
	rillai iv	iodule i	zxamma	ILIOII:							
	•			ination (Study Exa / Not Passed)	mina	ation, oral /	written l	Examiı	nation, V	Veight:	
8	Usabili	ity of th	ne Modu	ıle							
9	Literat	ure									

10	Comment

Mod	dule na									
no.	odule c. Credit Points -00- 5 CP		f Reaction Diffus Workload 150 h	Self-study		Duration 1 Semester		Frequency Irregular		
	Language of Instruction German and English				Person responsible for the Module Prof. Dr. rer. nat. Dieter Bothe					
1	Course	es of the	e Modu	le	l	1				
	Course no.		Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)268-vu		^r Analysis of Reactio n Systems	n	0		Lecture and Exercise		3
	Study Content semigroup approach to semilinear problems, existence and flow invariance, maximal regularity for solving quasilinear parabolic systems, global existence for prototype reaction-diffusion systems									
3	Learning Outcomes Students learn to - derive prototype models for reaction diffusion systems - formulate reaction diffusion systems as abstract evolution equations - to apply the semigroup approach for semilinear evolution equations to reaction diffusion systems - understand the concept of flow invariance and to apply it to reaction diffusion systems - understand the fundamental problems concerning the global existence of solutions and how to overcome these problems for prototype cases									
4	_			rticipation Differential Equat	ions	I				
5		Iodule I			Exar	nination, ora	al / writt	ten Exa	aminatio	on,

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

A.Pazy: Semigroups of linear operators and applications to Partial Differential Equations, Springer 1983.

J. Prüss, Maximal regularity for evolution equations in Lp-spaces. Lecture Notes, Monopoli 2002.

L. Lorenzi, A. Lunardi, G. Metafune, D. Pallara: Analytic Semigroups and Reaction-Diffusion Problems, Internet Lecture Notes 2005.1983.

M. Pierre. Global existence in reaction-diffusion systems with control of mass: a survey. Milan J. Math., 78, 417-455, 2010.

10 Comment

recommended: Mathematics: Master (ana) Builds on "Partial Differential Equations I".

Upon approval, contents of two PDE II.X-courses may replace "Partial Differential Equations II" and can be combined with the content from "Partial Differential Equations I" as an "Advanced Course in Analysis".

Combinations of two or more PDE II.X-courses as additional courses require approval, too.

Module name										
Game Theory										
Module no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-00- 0281	6 CP	180 h	135 h	1 Semester	Every 2. semester					

Lan	guage of Instru	uction	Person responsible for the Module						
Ger	man		Prof	. Dr. rer. nat. Stefa	an Ulbrich				
1	Courses of the	e Module							
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-00-0277-vu	Game Theory		0	Lecture and Exercise	3			
2	of solution of a (e.g. Brouwer) zero-sum game systems).	we game theory: sequentian a game (e.g. Nash equilibre), existence theorems (e.g. es) and impossibility theorems theory: coalitions, sol	rium) . min: rems	, fixed point theor imax theorem for t (e.g. Arrow parad	ems wo-player ox for voting				
3	Learning Outcomes Die Studenten verstehen grundlegende Konzepte der kooperativen oder nicht- kooperativen Spieltheorie. Sie modellieren einfache konkrete Situationen unter Verwendung präziser und abstrakter Begriffe. Sie wenden mathematische Theoreme an, um Spiele zu analysieren, und bewerten diese Vorhersagen für die Praxis								
4	_	for Participation athematisches Grundwiss	sen au	ıs den Fachsemest	ern 1-3				
5		Examination: e Examination (Technical	l Exai	nination, oral / wi	ritten Examinat	ion,			
	Standa	rd)							
6	Requirements	on the Award of Credit	Poin	ts					
7		Examination: e Examination (Technical) :: 100%, Standard)	l Exaı	nination, oral / wi	ritten Examinat:	ion,			
8	Usability of the B.Sc.Math:Wal	ne Module hlpflichtbereich, Ergänzur	ngsbe	reich					
9	Literature W. Krabs: Spie	eltheorie: Dynamische Beh	nandl	ung von Spielen. V	erlag B.G. Teul	oner 2005			
	Osborne, Mart	in J. (2004), An introduct	tion t	o game theory					

10	Comment

Module name													
Treff Module no. 04-00- 0297		fpunkt Mather Credit Points 0 CP		watik II für ET Workload 0 h	Self-stud		0 h	Duratio 1 Seme	_	Frequency Every 2. semester			
Language of Instruction			uction	Person resp				ponsible for the Module					
1 Courses of the Module													
1	Course no.		Course name			Workload (CP)			Form of Teaching		Contact Hours per Week		
	04-10-0405-tt Treffpu			nkt Mathematik II für ET		0			Convention 0		0		
3	Study Content Learning Outcomes												
4	Requirements for Participation												
5	Form of Examination												
6	Requirements on the Award of Credit Points												
7	Grading												
8	Usabil	ity of th	ne Modu	ıle									
9	Literat	ure											

10	Comment
	Verantwortlich: Studiendekan

Мо	dule na									
Module no. 04-00- 0298 Language		Credit Points 0 CP		matik II für Infor Workload 0 h	Self-study		Duratio 1 Seme	o n ester	Frequency Every 2. semester	
	man)i ilisti (uction		reis	on respons	ible for	tile ivi	louuic	
1				e name		Workload			n of ching	Contact Hours per Week
	04-10-0403-tt Treffpunkt Mathematik II für Informatik und Wirtschaftsinformatik						Convention 0			
2	Study	Conten	t							
3	Learni	ng Outo	comes							
4	Requir	ements	for Pa	rticipation						
5	Form o	of Exam	nination	ı						
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Grading									
8	Usabil	ity of th	ne Modu	ıle						
9	Literat	Literature								

10	Comment
	Verantwortlich: Studiendekan

Mod	lule na	me								
	Treff	punkt	Mather	natik für ET						
Mod no. 04-0	lule 00-			Workload 0 h	Self	- study 0 h	Duration 1 Semester		Frequency Every 2. semester	
Lan Geri		of Instru	action			son respons liendekan*i				
1	Course	es of the	e Modul	le						
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0)404-tt	Treffpu	nkt Mathematik I fü	r ET	0		Conve	ntion	0
2	Study Content									
3	Learni	ng Outo	comes							
4	Requir	ements	for Pai	rticipation						
5	Form o	of Exam	ination	1						
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradin	ıg								
8	Usabil	ity of th	ie Modu	ıle						
9	Literat	ure								
10	Comm	ent								

Verantwortlich: Studiendekan		

Мо	dule na		Matho	matik für Inform	atik ı	ınd W	'irtsc	haftsint	forma	+ib	
Module no. 04-00- 0301			edit Points 0 CP 0 h			f-study		Duration 1 Semester		Frequency Every 2. semester	
	nguage (of Instr	uction					ible for n des Fa			
1	Course no. Course name			Workload ((CP)	Forn Teac	n of ching	Contact Hours per Week		
	04-10-0402-tt Treffpunkt Mathematik I für Informatik und Wirtschaftsinformatik						Conve	ention	0		
2	Study	Conten		<u>uromormatin</u>							.1
3	Learni	ng Out	comes								
4	Requi	rements	s for Pa	rticipation							
5	Form	of Exan	nination	ı							
6	Requi	rements	on the	Award of Credit	Poin	ts					
7	Grading										
8	Usabil	ity of th	ne Modı	ıle							
9	Literature										

10	Comment

Verantwortlich: Studiendekan

Мо	dule na										
no. 04-	o. Credit Point 4-00- 0 C			matik für Maschi Workload 0 h	Self-study		0 h	Duration 1 Semester		Frequency Every 2. semester	
	i guage (man	of Instr	uction			_	-	ible for 1 des Fac			
1				e name	Workload ((CP)	Form of Teaching		Contact Hours per Week
	04-10-0406-tt Treffpunkt Mathematik I für 0 Maschinenbau						Conve	ntion	0		
2	Study	Conten	t								
3	Learni	ng Outo	comes								
4	Requir	ements	for Pa	rticipation							
5	Form o	of Exam	nination								
6	Requirements on the Award of Credit Points										
7	Grading										
8	Usabil	ity of th	ne Modu	ıle							
9	Literat	Literature									

10	Comment
10	COMMITTEE

Verantwortlich: Studiendekan

1													
Mod	lule na		Mather	natik II für Masc	hine	nhau							
Mod no. 04-0	lule)0-			Workload 0 h	Self-study		0 h	Duration 1 Semester		Frequency Every 2. semester			
		of Instr	uction	l	Person responsible for the Module Studiendekan*in des Fachbereichs 04								
Gen	man Course	es of the	e Modul	le	Stuc	liendek	an*11	i des Fac	hbere	ichs 04			
-				e name		Workload (CP)			Form of Teaching		Contact Hours per Week		
	04-10-0407-tt Treffpunkt Mathematik II für 0 Maschinenbau							Convention 0					
2	Study Content												
3	Learni	ng Out	comes										
4	Requir	ements	for Pa	rticipation									
5	Form o	of Exam	nination	1									
6	Requirements on the Award of Credit Points												
7	Grading												
8	Usabil	ity of th	ne Modu	ıle									
9	Literat	ure											

10 Comment

Verantwortlich: Studiendekan

Mod	lule na										
	Sign	al - Keiı	ne Aufl	agen oder Aufla	gen e	erfüllt					
Mod no. 04-0	Credit Points 00- 0 CP		Points 0 CP	Workload 0 h	Self-study 0 h		Duration 1 Semester		Frequency Every semester		
T		f In atus			Dana			:L1. f	41a n 17	-11-	
		of Instru	iction		Person responsible for the Module Studiendekan*in des Fachbereichs 0						
German					Stud	iendek	an*ii	n des Fac	chbere	ichs 04	
1	Course	es of the	e Modul	le							
	Course no. Cours			e name	` ′			Form Teac		Contact Hours per Week	
2	Study Content										
3	Learning Outcomes										
4	Requir	ements	for Pa	rticipation							
5	Form o	of Exam	ination	1							
	Final N	Iodule I	Zvamina	ition:							
	•			ination (Study Exa	ımina	tion, S _l	pecia	l Form,	Passed	d / Not P	assed)
6	Requirements on the Award of Credit Points										
7	Gradir Final M	Iodule I	e Exami	ition: ination (Study Exa	ımina	tion, S _l	pecia	l Form, V	Weigh	t: 100%,	Passed /
8	Usabil	ity of th	e Modu	ıle							

9	Literature
10	Comment
	Verantwortlich: Studiendekan

Mad	odule name									
Moc			ı bilingı	ıal						
Module		Credit Points 0 CP					Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German			ıction		Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Course	s of the	e Modul	le						
Course no. Course name Workload (CP)					(CP)	Form Teac	_	Contact Hours per Week		
2	Study	Conten	t							
3	Learni	ng Outo	comes							
4	Requir	ements	for Par	rticipation						
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed)									
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradin Final M	Iodule I Modul	Examina e Exami / Not Pa	ination (Study Exa	ımina	ntion, Study	Examina	tion, V	Weight: 1	100%,

8	Usability of the Module
9	Literature
10	Comment Verantwortlich: Studiendekan

Mod	lule na	me								
	Valid	lation								
Module no. Credit Points 04-00- 0 CP 9999		Workload 0 h	•		Duration 1 Semester		Frequency Every semester			
Language of Instruction German				Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	Course	es of the	e Modul	le						
	Course name					Workload	(CP)	Form of Teaching		Contact Hours per Week
2	Study	Conten	t							
3	Learni	ng Outo	comes							
4	Requir	ements	for Pai	rticipation						
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed)									
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradi r Final M	U	Examina	ition:						

	 Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
9	Literature
10	Comment Verantwortlich: Studiendekan

Mod	dule nai	me										
	Signa	al - keir	ne Aufl	age								
Mod no. 04-0		Credit Points 0 CP		Workload 0 h		- study 0 h	Duratio	-		ncy emester		
Language of Instruction German						Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	Course no. Course name					Workload (CP) Forr			n of hing	Contact Hours per Week		
2	Study	Conten	t									
3	Learni	ng Outo	comes									
4	Requir	ements	for Pa	rticipation								
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed)											
6	Requir	ements	on the	Award of Credit	Poin	ts						

7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
9	Literature
10	Comment Verantwortlich: Studiendekan

Mod	dule nar	ne									
	Stati	stics I									
Module no. 04-03- 0132		Credit Points 8 CP		Workload 240 h				Duration 1 Semester		Frequency Every 2. semester	
					son respons . Dr. rer. nat						
1	Course	s of the	e Modul	le							
	Course	Course no. Cour		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0116-vu Statistic		Statistic	es I		0		Lecture and Exercise		5	
2	- Erheb	C		im Rahmen von S	tudie	en und Umfr	agen				
				. Wahrscheinlichke	eitsm	aße					
	- Zufall	svariab	len und	Verteilungen							
	- Erwar	tungsw	ert und	Varianz							
	- Unabl	nängigk	eit								
	- Gesetz	z der gr	oßen Za	ahlen und zentrale	r Gre	enzwertsatz					

	- Punktschätzverfahren und statistische Tests, insbesondere Gauß und t-Test
3	Learning Outcomes Die Studierenden verfügen über ein grundlegendes Verständnis für die mathematische Modellierung des Zufalls und darauf aufbauender statistischer Schlussweisen. Sie haben ein Konzept zu statistischen Masszahlen, zur Dichte, dem Erwartungswert und der Varianz. Sie verstehen das Prinzip eines statistischen Tests.
4	Requirements for Participation Keine
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	Literature Agresti, A. and Tinlay, B. Statistical Methods for the Social Sciences. Prentice Hall. 2009. Eckle-Kohler, J. and Kohler, M. Eine Einführung in die Statistik und ihre Anwendungen. Springer. 2009.
10	Comment Verantwortlich: Herr Kohler (sto)

Module name										
Analysis I										
Module no. 04-10-	Credit Points 9 CP	Workload 270 h	Self-study 165 h	Duration 1 Semester	Frequency Every 2. semester					

000	1/de									
	guage of Instru	action	Pers	on respons	ible for	the M	odule			
Ger	man		Prof	Dr. rer. na	t. Matthi	as Hie	ber			
1	Courses of the	e Module								
	Course no.	Course name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0003-tt	Analysis I		0		Convention		1		
	04-00-0003-vu	Analysis I		0		Lectur Exerci	-	6		
2	of the real nundifferentiation	olex numbers, completenent olers, compactness, notio , Mean Value Theorem, Te chniques of integration.	n of a	function, c	ontinuity	, elem	nentary :	functions,		
4	Learning Outcomes After the completion of this course, the students are able to -analyse functions in one real variable using fundamental concepts such as limit, continuity, differentiability and Riemann integrability -prove mathematical results in this context with different methods of proof Requirements for Participation									
5	Form of Exam Final Module F									
	• Modul	e Examination (Study Exa	amina	ition, Specia	ıl Form,	Passe	d / Not	Passed)		
		e Examination (Technical on 90 min, Standard)	l Exan	nination, or	al / writt	en Ex	aminatio	on,		
	only a small nu	Usually the exam is taken amber of potential particing lexam. The decision abou	pants.	In this case	e, the exa	am car	n be take			
	during the first taking the exam	t two weeks of the lecture m.	e, base	ed on the pr	ospective	e num	ber of st	udents		
Studienleistung: Usually this means that the student successfully complete proportion of the homework assignments. The precise proportion of necessignments and the marking scheme will be communicated by the instruction first lecture.							cessary			
6	Requirements Passing the Fac	on the Award of Credit	Poin	ts						

	Passing the Studienleistung is a prerequisite for taking the Fachprüfung								
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 0%, Passed /								
	 Not Passed) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 								
8	Usability of the Module B.Sc. Mathematik, LaG Mathematik, B.Sc. Physik								
9	Literature H. Amman, J. Escher: Analysis II, Birkhäuser O. Forster: Analysis I, II. Vieweg M. Hieber: Analysis I, Springer K. Königsberger: Analysis 1, 2, Springer Charles R. MacCluer, Honors Calculus, Princeton Univ. Press W. Rudin: Principles of Mathematical Analysis, McGraw-Hill								
10	Comment recommended: Mathematics: Bachelor year 1, Teaching Degrees								

Mod	Module name										
	Analysis I (english)										
Mod no. 04-1	(Credit Points 9 CP Workload 270 h			Self-study Dura 165 h		Semester E		Frequency Every 2. semester		
Language of Instruction English					Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Courses of the Module										
	Course no. Cours			e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-00)40-tt	Analysis	I (english)		0		Conve	ntion	1	
	04-00-00)40-vu	Analysis	s I (english)		0		Lectur Exerci	-	6	
2	Study C	Content	t								
				nbers, completenes ompactness, notion							

differentiation, Mean Value Theorem, Taylor's Theorem, integral, Fundamental Theorem of Calculus, techniques of integration 3 **Learning Outcomes** After the completion of this course, the students are able to - analyse functions in one real variable using fundamental concepts such as limit, continuity, differentiability and Riemann integrability - prove mathematical results in this context with different methods of proof **Requirements for Participation** none Form of Examination 5 Final Module Examination: Module Examination (Study Examination, Special Form, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture. **Requirements on the Award of Credit Points** Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** B.Sc. Mathematik, LaG Mathematik, B.Sc. Physik 9 Literature

H. Amman, J. Escher: Analysis II, Birkhäuser

O. Forster: Analysis I, II. Vieweg M. Hieber: Analysis I, Springer

K. Königsberger: Analysis 1, 2, Springer

Charles R. MacCluer, Honors Calculus, Princeton Univ. Press W. Rudin: Principles of Mathematical Analysis, McGraw-Hill

10 Comment

recommended: Mathematics: Bachelor year 1

Module Description

no. 04-		Credit Points 9 CP		Workload 270 h	Self-study 165 h		Duration 1 Semester		Frequency Every 2. semester	
Lar	iguage o	f Instru	ıction		Pers	on respons	ible for	the M	odule	
Ger	man				Prof	Dr. rer. nat	. Matthi	as Hie	ber	
1	Course	s of the	e Modu	le	•					
	Course no.		Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0	04-00-0002-tt Analysi		; II		0		Conve	ntion	1
	04-00-0	04-00-0002-vu Analysi		s II 0				Lectur Exerci		6
2	Study Content Konvergenz von Funktionenfolgen, Potenzreihen, Topologie metrischer Räume, Normen, Differentialrechnung mehrerer Variablen, partielle Ableitungen, Ableitungsregeln, Gradient, Höhere Ableitungen und Satz von Taylor in mehreren Variablen Lokale Extrema Lokale Umkehrbarkeit und implizite Funktionen Kurven, Wege und Vektorfelder Konvergenz von Fourrierreihen Parsevalsche Gleichung									
3	Learning Outcomes									
	After the completion of this course, the students are able to -analyse functions in several real variable using fundamental concepts such as norms,									

continuity in normed spaces, partial and total differentiability and integrability

-investigate geometric properties in higher dimensional spaces using basic topological

concepts

4 Requirements for Participation

recommended: Analysis 1

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik, B.Sc. Physik

9 Literature

H. Amman, J. Escher: Analysis II, Birkhäuser

O. Forster: Analysis I amp; II. Vieweg

M. Hieber: Analysis II, Springer

K. Königsberger: Analysis 1,2, Springer

W. Rudin: Principles of Mathematical Analysis, McGraw-Hill

10 Comment

recommended: Mathematics: Bachelor year 1, Teaching Degrees

wio d	uic De	scriptio	<u> </u>							
Mod	dule na	me								
		ysis II (english	1)	ı		T .		1	
no. 04-1	Module no. Ci 04-10- 0002/en		Points 9 CP	Workload 270 h		-study 165 h	Duration 1 Semester		Frequency Every 2. semester	
Lan Eng	guage o	of Instru	action			son respons				
1		es of the	e Modu	le		F				
	Course			e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0	011-tt	Analysis	s II (english)		0		Conve	ention	1
	04-00-0011-vu Analysi		s I (englisch)	glisch) 0			Lectur Exerci		6	
	Ableitu Höhere Lokale Lokale Kurven Konver	ngsrege Ableitu Extrem Umkeh Wege genz vo	eln, Grad ingen u a rbarkeit und Vel	nd Satz von Taylo und implizite Fun ktorfelder ierreihen	r in n	nehreren Va		tunger	Π,	
3	Learning Outcomes After the completion of this course, the students are able to - analyse functions in several real variable using fundamental concepts such as norms, continuity in normed spaces, partial and total differentiability and integrability - investigate geometric properties in higher dimensional spaces using basic topological concepts									
4	_		for Par	rticipation is 1						
5		Iodule I	ination Examina e Exam		ımina	ntion, Specia	ıl Form,	Passed	d / Not ː	Passed)

• Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik, B.Sc. Physik

9 Literature

H. Amman, J. Escher: Analysis II, Birkhäuser

O. Forster: Analysis I amp; II. Vieweg

M. Hieber: Analysis II, Springer

K. Königsberger: Analysis 1,2, Springer

W. Rudin: Principles of Mathematical Analysis, McGraw-Hill

10 Comment

recommended: Mathematics: Bachelor year 1

Module name									
Analysis									
Module	Credit Points	Workload	Self-study	Duration	Frequency				

no. 04-10- 0003/de	18 CP	540 h	300 h	2 Semester	Every 2. semester	
Language o	of Instruction		Person responsible for the Module			
German			Prof. Dr. rer. nat. Matthias Hieber			

1 Courses of the Module

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0002-tt	Analysis II	0	Convention	2
04-00-0002-vu	Analysis II	0	Lecture and Exercise	6
04-00-0003-tt	Analysis I	0	Convention	2
04-00-0003-vu	Analysis I	0	Lecture and Exercise	6

2 Study Content

Part 1: Real and complex numbers, completeness, convergence of sequences and series, topology of the real numbers, compactness, notion of a function, continuity, elementary functions, differentiation, Mean Value Theorem, Taylor's Theorem, integral, Fundamental Theorem of Calculus, techniques of integration.

Part 2: Convergence of sequences of functions, power series, topology of metric spaces, norms on Rn, differentiation of functions of several variables, partial derivatives, rules of differentiation, gradient, higher derivatives and Taylor's theorem in several variables, local extrema, inverse and implicit function theorems, integration on Rn, curves in Rn, integral theorems of Gauß and Stokes

3 Learning Outcomes

Teil 1: Nach dem Besuch des Moduls können die Studierenden

- Funktionen einer reellen Variablen mit grundlegenden Konzepten (Grenzwert, Stetigkeit, Differenzierbarkeit, Vollständigkeit usw.) analysieren
- mathematische Schlussfolgerungen mit verschiedenen Beweismethoden herleiten Teil 2: Nach dem Besuch des Moduls können die Studierenden
- Funktionen, die von mehreren Variablen abhängen, mit grundlegenden Konzepten (Stetigkeit, totale und partielle Differenzierbarkeit, Integration) analysieren
- geometrische Zusammenhänge in mehrdimensionalen Räumen mit topologischen Grundkonzepten untersuchen

4 Requirements for Participation

keine

5 Form of Examination

Final Module Examination:

• Module Examination (Technical Examination, Technical Examination, Standard)

	Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module 1. Jahr Bachelor
9	Literature O. Forster: Analysis I, II. Vieweg H. Heuser: Lehrbuch der Analysis 1, 2, Teubner K. Königsberger: Analysis 1, 2, Springer Charles R. MacCluer, Honors Calculus, Princeton Univ. Press W. Rudin: Principles of Mathematical Analysis, McGraw- Hill
10	Comment

Mod	Module name												
	Analysis (english)												
Module no. 04-10- 0003/en		Credit	Points 18 CP	Workload	540 h		- study 300 h	Duration 2 Semester		Frequency Every semester			
	Language of Instruction English Courses of the Module					Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber							
	Course no. Cour		Course	e name			Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0	011-tt	Analysis	s II			0		Conve	ntion	2		
	04-00-0	0011-vu	Analysis	s II			0		Lectur	e and	6		

				Exercise	
04-0	0-0040-tt	Analysis I	0	Convention	2
04-0	0-0040-vu	Analysis I	0	Lecture and Exercise	6

2 Study Content

Part 1: Real and complex numbers, completeness, convergence of sequences and series, topology of the real numbers, compactness, notion of a function, continuity, elementary functions, differentiation, Mean Value Theorem, Taylor's Theorem, integral, Fundamental Theorem of Calculus, techniques of integration

Part 2: Convergence of sequences of functions, power series, topology of metric spaces, norms on Rn, differentiation of functions of several variables, partial derivatives, rules of differentiation, gradient, higher derivatives and Taylor's theorem in several variables, local extrema, inverse and implicit function theorems, integration on Rn, curves in Rn, integral theorems of Gauß and Stokes

3 Learning Outcomes

Teil 1: Nach dem Besuch des Moduls können die Studierenden

- Funktionen einer reellen Variablen mit grundlegenden Konzepten (Grenzwert, Stetigkeit, Differenzierbarkeit, Vollständigkeit usw.) analysieren
- mathematische Schlussfolgerungen mit verschiedenen Beweismethoden herleiten

Teil 2: Nach dem Besuch des Moduls können die Studierenden

- Funktionen, die von mehreren Variablen abhängen, mit grundlegenden Konzepten (Stetigkeit, totale und partielle Differenzierbarkeit, Integration) analysieren
- geometrische Zusammenhänge in mehrdimensionalen Raeumen mit topologischen Grundkonzepten untersuchen

4 Requirements for Participation

keine

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Standard)
- Module Examination (Study Examination, Study Examination, Passed / Not Passed)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)

8	Usability of the Module 1. Jahr Bachelor
9	Literature O. Forster: Analysis I, II. Vieweg H. Heuser: Lehrbuch der Analysis 1, 2 Teubner K. Königsberger: Analysis 1, 2, Springer Charles R. MacCluer, Honors Calculus, Princeton Univ. Press W.Rudin: Principles of Mathematical Analysis, McGraw-Hill
10	Comment

Mod	Module name										
	Line	ar Alge	bra I								
Mod no. 04-1		Credit Points 9 CP		Workload 270 h			Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German					Person responsible for the Module Prof. Dr. rer. nat. Martin Otto						
1	Course	es of the	e Modul	le							
	Course no. Cou		Course	se name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0042-tt Linear Algebra I		Algebra I		0		Conve	ntion	1		
	04-00-0)042-vu	Linear A	Algebra I				Lectur Exerci		6	
2	basic n linear o	depende	and concence, base	cepts, algebraic str ses, dimension; lin linear maps and n	ear a	and affine su	bspaces.		-		
3	Learning Outcomes Students are familiar with the basic concepts of abstract linear algebra. They can relate the axiomatic treatment to relevant concrete settings, problem solving tasks and elementary geometric concepts. They can reason and conduct rigorous arguments in the abstract axiomatic framework at a basic level. They know and can apply and analyse relevant basic constructions in algebra.										
4	Requir	ements	for Pa	rticipation							

none

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

9 Literature

Bosch: Lineare Algebra

Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie

Fischer: Lineare Algebra

Greub: Linear Algebra (auch deutsch)

Koecher: Lineare Algebra und Analytische Geometrie

10 Comment

recommended: Mathematics: Bachelor year 1

communicated

Мо	dule na									
no. 04-	dule	ar Alge Credit		Workload 270 h		E-study 165 h	Duratio 1 Seme		Freque Every 2 semest	2.
Lar	iguage o	of Instr	uction			son respons			odule	
1	1	es of the	e Modu	le						
			Cours	e name		Workload	(CP)	Forn Teac	n of hing	Contact Hours per Week
	04-00-0041		Linear A	Algebra I		0		Conve	ention	1
Ì	04-00-0	0041-vu	Linear A	Algebra I		0		Lecture and Exercise		6
3	Learni Studen the axi elemen abstrace	ng Outonts are factoristic are factoristic are generally generally generally are axiom	comes amiliar v treatme ometric natic fran	ses, dimension; linear maps and no with the basic conductor to relevant concepts. They can nework at a basic ctions in algebra.	cepts crete n rea	of abstract l settings, pro	inear alg	gebra. lving t	They ca asks and	n relate d nts in the
4	_			rticipation						
5	_	recommended: none Form of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)								
	_	_	•	the exam is taken f potential particip				_		

form of an oral exam. The decision about the form of the exam is taken and

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

9 Literature

Bosch: Lineare Algebra

Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie

Fischer: Lineare Algebra

Greub: Linear Algebra (auch deutsch)

Koecher: Lineare Algebra und Analytische Geometrie

10 Comment

recommended: Mathematics: Bachelor year 1

Module Description

Module name Linear Algebra II Module Frequency no. **Credit Points | Workload** Self-study Duration Every 2. 04-10-9 CP 270 h 165 h 1 Semester semester 0005/de **Language of Instruction** Person responsible for the Module German Prof. Dr. rer. nat. Martin Otto **Courses of the Module**

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0008-tt	Linear Algebra II	0	Convention	1
04-00-0008-vu	Linear Algebra II	0	Lecture and Exercise	6

2 Study Content

systems of linear equations; eigenvalues and diagonalisation of endomorphisms; characteristic an minimal polynomials in the ring of univariate polynomials; Jordan normal form; euclidean and unitary spaces; bilinear forms, quadratic forms, quadrics; possible excursions: affine and projective geometry, geometry of conic sections, or elements of multilinear algebra

3 Learning Outcomes

Students are familiar with central concepts and techniques of linear algebra. They have acquired an understanding of the relevant abstract algebraic notions and can apply them in other areas of mathematics as well as relate them to underlying geometric concepts.

4 Requirements for Participation

recommended: Linear Algebra 1

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

 Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

9 Literature

Bosch: Lineare Algebra

Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie

Fischer: Lineare Algebra

Greub: Linear Algebra (auch deutsch)

elements of multilinear algebra

Koecher: Lineare Algebra und Analytische Geometrie

10 Comment

recommended: Mathematics: Bachelor year 1

Mod	Module name										
Linear Algebra II											
Module no. Credit Poin		Points 9 CP	Workload 270		Self-	study 165 h	Duration 1 Semester		Frequency Every 2. semester		
	Language of Instruction English						on respons Dr. rer. nat			odule	
1	Course	s of the	e Modul	le							
	Course no. Course name								Form Teac		Contact Hours per Week
	04-00-0	012-tt	Linear A	Algebra II		0			Convention		1
	04-00-0	012-vu	Linear A	Algebra II				Lecture and Exercise		6	
2	Study Content systems of linear equations; eigenvalues and diagonalisation of endomorphisms; characteristic an minimal polynomials in the ring of univariate polynomials; Jordan normal form; euclidean and unitary spaces; bilinear forms, quadratic forms, quadrics; possible excursions: affine and projective geometry, geometry of conic sections, or										

3 Learning Outcomes

Students are familiar with central concepts and techniques of linear algebra. They have acquired an understanding of the relevant abstract algebraic notions and can apply them in other areas of mathematics as well as relate them to underlying geometric concepts.

4 Requirements for Participation

recommended: Linear Algebra 1

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

9 Literature

Bosch: Lineare Algebra

Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie

Fischer: Lineare Algebra

Greub: Linear Algebra (auch deutsch)

	Koecher: Lineare Algebra und Analytische Geometrie
10	Comment
	recommended: Mathematics: Bachelor year 1

Mod	Module name										
	Linear Algebra										
Mod no.		Credit		Workload	_		•	Duratio		Freque	•
04-1	10- 6/de		18 CP		540 h		300 h	2 Semes	ster	Every se	emester
Lan	guage (of Instr	uction			Pers	on respons	ible for	the M	odule	
Geri	man					Prof. Dr. rer. nat. Nils Scheithauer					
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0	0008-tt	Linear A	Algebra II	•		0		Conve	ntion	2

Lecture and Exercise

Convention

Lecture and

Exercise

2

6

2 Study Content

04-00-0008-vu | Linear Algebra II

04-00-0042-tt | Linear Algebra I

04-00-0042-vu | Linear Algebra I

Part 1: basic notions and concepts, algebraic structures (groups, rings, fields); vector spaces, linear dependence, bases, dimension; linear and affine subspaces, products, sums and quotients, dual space; linear maps and matrices; determinants;

0

0

Part 2: systems of linear equations; eigenvalues and diagonalisation of endomorphisms; characteristic an minimal polynomials in the ring of univariate polynomials; Jordan normal form; euclidean and unitary spaces; bilinear forms, quadratic forms, quadrics; possible excursions: affine and projective geometry, geometry of conic sections, or elements

of multilinear algebra

3 Learning Outcomes

Die Studierenden können die Konzepte der linearen Algebra in verschiedenen Zusammenhängen erkennen, anwenden und erklären. Sie lernen insbesondere, abstrakt-axiomatisch Begriffsbildungen der linearen Algebra auf einschlägige Probleme anzuwenden, mit geometrischen Begriffen in Verbindung zu bringen, typische Aufgaben zu lösen und einfache Beweise zu führen.

4	Requirements for Participation keine
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard) • Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module Grundstudium Mathematik
9	Literature Bosch: Lineare Algebra Brieskorn: Lineare Algebra und Analytische Geometrie Bröcker: Lineare Algebra und Analytische Geometrie Fischer: Lineare Algebra Greub: Linear Algebra (auch deutsch) Koecher: Lineare Algebra und Analytische Geometrie
10	Comment

Module name											
Linear Algebra											
Module no.	Credit Points	Workload	Self-study	Duration	Frequency						
04-10- 0006/en	18 CP	540 h	300 h	2 Semester	Every 2. semester						
Language (English	of Instruction		Person responsible for the Module Prof. Dr. rer. nat. Nils Scheithauer								

1	Courses of the Module											
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week							
	04-00-0012-tt	Linear Algebra II	0	Convention	2							
	04-00-0012-vu	Linear Algebra II	0	Lecture and Exercise	6							
	04-00-0041-tt	Linear Algebra I	0	Convention	2							
	04-00-0041-vu	Linear Algebra I	0	Lecture and Exercise	6							
	Part 1: basic notions and concepts, algebraic structures (groups, rings, fields); vector spaces, linear dependence, bases, dimension; linear and affine subspaces, products, sums and quotients, dual space; linear maps and matrices; determinants; Part 2: systems of linear equations; eigenvalues and diagonalisation of endomorphisms; characteristic an minimal polynomials in the ring of univariate polynomials; Jordan normal form; euclidean and unitary spaces; bilinear forms, quadratic forms, quadrics; possible excursions: affine and projective geometry, geometry of conic sections, or elements of multilinear algebra											
3	contexts, and tapply abstract- them with geo	ne able to recognise the conc to apply and explain them. In axiomatic notions of linear a metric concepts, to solve typ	n particular, they will algebra to typical prol	have learnt to blems, to conne								
4	keine	s for Participation										
5		Examination: le Examination (Technical Ex le Examination (Study Exam	•	-								
6	Requirements	s on the Award of Credit Po	ints									
7		Examination: le Examination (Technical Ex Standard)	zamination, Technical	l Examination,	Weight:							

	Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	Grundstudium Mathematik
9	Literature
	Bosch: Lineare Algebra
	Brieskorn: Lineare Algebra und Analytische Geometrie
	Bröcker: Lineare Algebra und Analytische Geometrie Fischer: Lineare Algebra
	Greub: Linear Algebra (auch deutsch)
	Koecher: Lineare Algebra und Analytische Geometrie
10	Comment

Module name											
	Intro	ductio	n to Ma	athematical	Soft	ware	9				
Module no. 04-10- 0009/en		Credit Points 3 CP				Semestration 60 h Duration 1 Semestration 1 Semestrati		Every 2		2.	
Language of Instruction English Person responsible for the Module											
1	Courses of the Module										
	Course no. Course name				Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0	0045-vl	Introdu Softwar	ction to Mathe e	ematic	al	0 Lectu			re	2
2	Study Content Contents of Linear Algebra 1 and Analysis 1 are incorporated. Software supported symbolic and numerical solution of elementary and basic mathematical problems. For instance, Mathematica or Maple: matrix arithmetic and systems of linear equations, difference between symbolic and numerical computation, differentiation and integration; limits and series; graphics and and visualisation; definition of functions and programming.										
3	Learning Outcomes Nachdem Studierende das Modul besucht haben, können sie mindestens o ein allgemeines mathematisches Softwarepaket bedienen, sowie										

	o einfache mathematische Sachverhalte algorithmisch umsetzen.
4	Requirements for Participation keine
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed)
	Verantwortlich: AG Optimierung
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)
8	Usability of the Module Für B.Sc.Math, B.Sc.Math (bilingual), B.Sc.WiMa, B.Sc.MCS, B.Sc.ME: Pflicht
9	Literature David Withoff: Mathematica Tutorials, http:#47;#47;library.wolfram.com#47;conferences#47;devconf99#47; withoff#47;index2.html
	MapleSoft Application Center, [url]http:#47;#47;www.maplesoft.com#47;applications#47;[/url]
10	Comment

Module name											
Introduction to scientific programming											
Module no.	Credit Points	Workload		Self-study	Duration	Frequency					
04-10- 0010/de	3 CP		90 h	45 h	1 Semester	Every 2. semester					
Language German	of Instruction			Person responsible for the Module							

1	Courses of the	e Module							
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-00-0009-ku	Introduction to scientific programming	0	Course	3				
2	Study Content Introduction to a programming language (Matlab, C, etc.), data types, expressions, standard functions, vector operations, boolean operations, control flow statements, input, output, subroutines, graphics.								
3	Learning Outcomes Die Studierenden können grundlegende Techniken des wissenschaftlichtechnischen Programmierens anhand einer Programmiersprache wiedergeben und beschreiben und durch sicheren und vertrauten Umgang mit der Sprache zur Umsetzung vorgelegter numerischer Algorithmen anwenden. Sie sollen Algorithmen effizient und klar strukturiert implementieren, und auf leicht modifizierte Problemstellungen anpassen können.								
4	Requirements	s for Participation							
5	Form of Exam Final Module I • Modul Passed	Examination: le Examination (Study Examin	ation, Study Examir	nation, Passed	/ Not				
6	Requirements	s on the Award of Credit Poir	nts						
7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)								
8	Usability of th Pflichtmodul	ne Module							
9	Literature Matlab User G	uide							
10	Comment Verantwortlich	n: AG Optimierung							

taking the exam.

Mod	dule na	ma									
MOC				tie d.							
no. 04-1	Module		ial Equations Workload 150 h	•		Duration 1 Semester		Frequency Every 2. semester			
Lan		of Instru	uction		Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Course	es of the	e Modu	le	ı						
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0)054-vu	Ordinar	y Differential Equat	ions	0		Lectur Exerci		3	
2	Study Content Separation of variables, Theorems of Picard-Lindelöf and Peano, local and global theory, linear systems of first and higher order, variation of constants formula, linearised stability, Lyapunov stability.										
3	Studen - under - devel	rstand a op a bas	nd are a sic level	able to apply the n of understanding the treated conce	of th	e theory of c	ordinary	differe	ential eq		
4	_			rticipation is and Linear Alge	bra						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) • Module Examination (Study Examination, Special Form, Passed / Not Passed) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and										
		communicated decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students									

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture. **Requirements on the Award of Credit Points** Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) **Usability of the Module** B.Sc. Mathematik, LaG Mathematik, B.Sc. Physik M.Sc. ETIT Literature H. Amann: Gewöhnliche Differentialgleichungen, de Gruyter W. Walther: gew. DGL, Springer 10 Comment recommended: Mathematics: Bachelor year 2, Teaching Degrees

Module name											
Complex Analysis											
Module no. 04-10-0012/de		Credit	Credit Points 5 CP		150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German						Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber					
1	Courses of the Module										
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per Week

	04-00-0225-vu	Complex Analysis	0	Lecture and Exercise	3						
2	Formula; analy	t nn differential equations, cur rticity, Liouville's Theorem an ent series and isolated singula	d Fundamental Theo	rem of Algebr							
3	the course- dev - understand a - develop a bas - are able to re understanding	erstand and are able to apply velop a Students and are able to apply the notion of level of understanding of Coognise the treated concepts of the Complex Analysis - are of mathematics.	ons, methods and resu Complex Analysis in various fields of m	ılts treated in athematics.bas	the course						
4	_	Requirements for Participation recommended: Analysis and Linear Algebra									
5	• Modul Fachprüfung (' test, except wheexam can be taken and co		nation, Special Form, ally the exam is taken nber of potential part am. The decision abo two weeks of the lect	Passed / Not in form of a v ticipants. In th out the form of	Passed) written is case, the the exam						
6	Passing the Fac	on the Award of Credit Poichprüfung; Idienleistung is a prerequisite		rüfung							
7	 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) 										
8	Usability of th B.Sc. Mathema	ne Module ntik, LaG Mathematik									

9 Literature Freitag: Funktionentheorie I, Springer Remmert: Funktionentheorie I Conway: Functions of one complex variable, Springer 10 Comment recommended: Mathematics: Bachelor year 2, Teaching Degrees

no. 04-2	dule 10- 3/de	Credit	Points 9 CP	Workload 270 h	Self-	- study 180 h	Duration 1 Semester		Frequency Every 2. semester	
	guage (man	of Instru	action			on respons . Dr. rer. nat			odule	
1	Courses of the Module Course no. Course name					Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0056-vu Introduction to Numerica Analysis					0		Lectur Exerci		6
2	error a linear a least so interpo	quares p lation a	linear sy roblems nd appi l differe	oximation entiation	ıs					
3	The stu		re able	to describe, explai have the ability to				•		al
4	Requirements for Participation recommended: Analysis and Linear Algebra, Introduction to Scientific Programming									
5		of Exam Module I Modul	Examina		mina	ition, Specia	l Form,	Passed	d / Not	Passed)

 Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

M.Sc. ETIT

9 Literature

Deuflhard, Hohmann: Numerical Analysis in Modern Scientific Computing: An Introduction; Texts in Applied Mathematics 43, Springer 2003.

Stoer, Bulirsch: Introduction to Numerical Analysis; Texts in Applied Mathematics 12, Springer 2002

Matlab User Guide

10 Comment

recommended: Mathematics: Bachelor year 2, Teaching Degrees

Module Description

Module name

	Wor	king sk	ills in m	nathematic	:s								
no. 04-1	dule 10- 4/de	Credit	Points 2 CP	Workload	60 h		- study 60 h	Duratio 1 Semes		Freque Every semest	2.		
	guage (of Instru	uction			Pers	on respons	ible for	the M	odule			
Ger	man					Stuc	Studiendekan*in des Fachbereichs 04						
1	Course	es of the	e Modul	le			T		ı				
	Course	e no.	Course	e name			Workload	(CP)	Form Teac	-	Contact Hours per Week		
	04-00-0	146-ku	Working	g skills in ma	themat	ics	0		Course	e	0		
2	Techni writing technic examp	of mat ques for les, feed	writing hematic the pres l back ar	al texts, ma	thema mathe	tical 1	erature seard typesetting p cal material	orograms	5,				
3	3 Learning Outcomes Nach dem Besuch des Moduls können die Studierenden fachspezifiche und grundlegende Schreib-und Arbeitstechniken nutzen sowie Präsentationsund Diskussionstechniken anwenden, insbesondere zu mathematischen Sachverhalten.							•					
4	_		s for Pai	rticipation Algebra									
5		Iodule I		tion:	dy Exa	ımina	ition, Study	Examina	ition,	Passed	/ Not		
6	Requir	ements	on the	Award of (Credit	Poin	ts						
7	Gradin Final M	Iodule I Modul	Examina le Exami / Not P	ination (Stu	dy Exa	ımina	ntion, Study	Examina	ition, \	Weight:	: 100%,		
8		•	ne Modu atik, Wa	ıle hlpflichtber	eich Ü								
9		spacher:		oBdA trivia spiech: Schi		_	rudium: ein	Training	sprogi	ramm C	Cornelsen		

Doob et al.: A manual for authors of mathematical papers, AMS
Higham: Handbook of Writing for the Mathematical Scienes, SIAM
Kämer: Wie schreibe ich eine Seminar-oder Examensarbeit?
Fischer van Gasteren: On the shape of mathematical arguments, Springer

Comment
Verantwortlich: Studiendekan

Mod	dule na	me								
	Inte	gration	Theory	y						
no. 04-1	dule 10- 5/de	Credit	Points 9 CP	Workload 270 h	Self-study 180 h Duration Every 2 semester				2.	
	German				Person responsible for the Module Prof. Dr. rer. nat. Moritz Egert					
1	Courses of the Module									
Teaching Hou per							Contact Hours per Week			
	04-10-0015-vu Integration Theory				0 Lecture and 6 Exercise				6	
2	Part I: measu: Fubini ²	re; meas s theore Convol	lgebras, surable em in R	measures, outer r functions, Lebesgu n change of varia tegrals, Fouriertra Green's theorem, S	ie into ables insfoi	egral, conve formula. m; Subman	rgence ti	heorer	ns, Lp-s	paces,
3 Learning Outcomes After participation in this module students are able to - sketch the derivation of measures, construct a generalized notion of integration and compare it with the classical Riemann integral, - choose and apply suitable theorems of convergence, - extend notions from measure and integration theory to submanifolds and apply integral theorems of vector calculus										
4	_			rticipation is and Linear Alge	bra					

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

9 Literature

J. Elstrodt: Mass-und Integrationstheorie, Springer

O. Forster: Analysis 3, Vieweg

S. Lang: Real Analysis, Addison-Wesley H.Amann, J.Escher: Analysis III, Birkhäuser

10 Comment

recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mod	lule na	me									
	Integ	gration	Theory	<i>/</i> I							
Mod no. 04-1		Credit	Points 4 CP	Workload 120 h	Self	-study 30 h		Duration 1 Semester Frequency Ever semes			
	guage o	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Moritz Egert						
1	Course	s of the	e Modul	le							
Teac								_	Form of Con- Teaching Hou per Wee		
	04-00-0	013-vu	Integrat	ion Theory I		0		Lectur Exerci		6	
2 Study Content Measures, measure space, Theorem of Caratheodor mesurable functions, integrable functions, Lebesgu theorems, Lp spaces, Fubini's theorem, change of v					besgue integ	gral, conv	vergen	.ce	ions.		
3	Nach d	erleitun	uch des g von M	Moduls können di aßen skizzieren u em klassischen Rie	nd ei	nen verallge			egralbeg	griff	
	- in An	wendun	gen gee	ignete Konvergen	zsätz	e auswählen	und erk	lären			
4	_	ements is und L		rticipation Algebra							
5											
6	Requir	ements	on the	Award of Credit	Poin	ts					
7	Gradin	g									

Final Module Examination:

- Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)

8 Usability of the Module

Für B.Sc.WiMa, B.Sc.Mamp;E: Pflicht Für M.Ed.Math, LaG.Math: als mathematische Ergänzung Für B.Sc.Phys: als nichtphys. Ergänzungsfach

9 Literature

- J. Elstrodt: Mass-und Integrationstheorie, Springer
- S. Lang: Real Analysis, Addison-Wesley H.Amann, J.Escher: Analysis III, Birkhäuser

10 Comment

Verantwortlich: NF Farwig (ana)

Mod	lule na	me									
	Integ	gration	Theory	/ II							
Mod no. 04-1 001		Credit	Points 5 CP	Workload 150 h	Self-study Duration 60 h 1 Semester			Frequency Every 2. semester			
Lan	guage o	of Instru	ıction		Person responsible for the Module						
Geri	nan				Prof	. Dr. rer. nat	t. Moritz	Egert			
1 Courses of the Module											
	Course	e no.	Course	e name	Workload		` '		n of hing	Contact Hours per Week	
	04-00-0)143-vu	Integrat	ion Theory II		0 Lecture and Exercise				6	
2	Study Content Convolution integrals, Fouriertransform; Submanifolds, surface measures, divergence theorem, Green's theorem, Stokes' theorem.										
3	Nach d		uch des	Moduls können di nsbegriffe auf Unte			ten				

	erweitern und im Kontext von Integralsätzen kombinieren
4	Requirements for Participation
	Analysis, Lineare Algebra und Integrationstheorie I (Wima)
5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Standard)
	 Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
	 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	Für B.Sc.WiMa, B.Sc.ME: math. Wahlbereich
9	Literature
	O. Forster: Analysis 3, Vieweg; S. Lang: Real Analysis, Addison-Wesley;
	H. Amann, J. Escher: Analysis III, Birkhäußer
10	Comment
	Verantwortlich: NF Farwig (ana)

Mod	lule na	me								
Introduction to Algebra										
Mod no.	lule	Credit Points	Workload	Self-study	Duration	Frequency				
04-1 001	10- 8/de	5 CP	150 h	105 h	1 Semester	Every 2. semester				
Lan Geri		of Instruction		Person responsible for the Module Prof. Dr. rer. nat. Jan Hendrik Bruinier						
1	1 Courses of the Module									

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0006-vu	Introduction to Algebra	0	Lecture and Exercise	3
Ct., d., Camtan				

2 Study Content

Elementary group theory, group actions, rings, divisibility, polynomial rings, modules.

3 Learning Outcomes

Students understand the basic notions and methods in the theory of groups, rings and modules. They are able to apply those to typical problems in the area.

4 Requirements for Participation

recommended: Linear Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 | Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8	Usability of the Module B.Sc. Mathematik, LaG Mathematik
9	Literature S. Lang: Algebra, Addison-Wesley; N. Jacobson: Basic Algebra 1, Freeman S. Bosch: Algebra, Springer
10	Comment recommended: Mathematics: Bachelor year 2

Mod	dule na	me									
	Intro	oductio	n to St	ochastics							
no. 04-1	dule 10- 9/de	Credit	Points 9 CP	Workload 270 h	Self	-study 180 h	Duratio 1 Semes		Freque Every 2 semeste		
	nguage of Instruction				Person responsible for the Module Prof. Dr. rer. nat. Michael Kohler						
1	Course	es of the	e Modu	le	I						
	Course	e no.	Cours	e name				Form Teac	n of hing	Contact Hours per Week	
	04-00-0	0004-vu	Introdu	ction to Stochastics	0 Lectur Exerci:			6			
2	Study Content Probability spaces and random variables, distribution functions, expectation and variance, independence and elementary conditional expectations, discrete and absolutely continuous distributions, Law of Large Numbers, Central Limit Theorem, estimation and confidence intervals, testing under the hypothesis of normality. Application and analysis of selected basic models of probability theory. Possible societal implications will be addressed in the lecture.										
3		* * *									

-be able to describe the most important ideas and results about probability and statistics based on simple models.

-know some of the most important methods of probability and statistics in the context of simple models.

-be able to transfer these methods to similar problems.

Students are able to contextualize subject matter within the social context, critically

assess the consequences, and act ethically and responsibly accordingly.

4 Requirements for Participation

recommended: Analysis and Linear Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, LaG Mathematik

M.Sc. ETIT

9 Literature

Eckle-Kohler, Kohler: Eine Einführung in die Statistik und ihre Anwendungen;

Irle: Wahrscheinlichkeitstheorie und Statistik;

Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik;

Georgii: Stochastik: Einführung in die Wahrscheinlichkeitstheorie und Statistik;

10 Comment

recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mod	lule na		D:	4 - 8.6 - 41 41						
no. 04-1	lule			te Mathematics Workload 150 h				Duration 1 Semester		ncy er
Lan Geri	guage o	of Instru	uction			son respons . Dr. Yann D		the M	odule	
1	Course	es of the	e Modu	le	I.					
	Course no. Course name					Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0005-vu Algorithmic Discrete Mathematics					0		Lectur Exerci		3
	Graph theory, growth of functions and asymptotic analysis of complexity, algorithms for spanning trees, shortest paths, matchings in bipartite graphs and flows in directed graphs, NP-completeness, searching and sorting. Possible additional topics: coding/cryptography, more graph algorithms, e.g., min-cost flows									
3	After a	orithmi	g this co	urse, students will pint on the exampl				-		derstand
4				rticipation is, Linear Algebra						
5	Form of Examination Final Module Examination:									
	•			ination (Technical) in, Standard)	Exar	nination, ora	al / writt	en Exa	aminatio	n,
	•	Modul	e Exam	ination (Study Exa	ımina	ntion, Specia	l Form,	Passed	d / Not F	Passed)

	Fachprüfung: In der Regel erfolgt die Prüfung durch eine Klausur, bei geringer Teilnehmerzahl gegebenenfalls mündlich. Die Form der Prüfung wird anhand der voraussichtlichen Teilnehmerzahl in den ersten beiden Veranstaltungswochen festgelegt.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung;
	Passing the Studienleistung is a prerequisite for taking the Fachprüfung
	rusbing the studiementaling is a prerequisite for taking the ruenprurung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
	Module Examination (Study Examination, Special Form, Weight: 0%, Passed /
	Not Passed)
8	Usability of the Module
	B.Sc. Mathematik, LaG Mathematik
_	
9	Literature
	M. Aigner, Diskrete Mathematik, 5. Auflage, Vieweg, 2003.
	T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein: Introduction to algorithms, 2. Auflage,
	BT, 2001.
	B. Korte, J. Vygen: Combinatorial Optimization, Springer 2012.
	J. Matoušek, J. Nešetril, Diskrete Mathematik. Eine Entdeckungsreise, Springer, 2002.
10	Comment
	recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mod	Module name										
	Algorithmic Discrete Mathematics										
Module no. Credit Points Workload 04-10- 5 CP 150 h 0020/en				study 105 h	Duration 1 Semester		Frequency Every 2. semester				
Lan Eng	0	of Instru	ıction			Person responsible for the Module Prof. Dr. Yann Disser					
1	Course	es of the	e Modul	le							
	Course no. Course name							Form Teac		Contact Hours per Week	

	04-00-0005-vu Algorithmic Discrete 0 Lecture and Exercise 3
2	Study Content Graph theory, growth of functions and asymptotic analysis of complexity, algorithms for spanning trees, shortest paths, matchings in bipartite graphs and flows in directed graphs, NP-completeness, searching and sorting. Possible additional topics: coding/cryptography, more graph algorithms, e.g., min-cost flows
3	Learning Outcomes After attending this course, students will know basic discrete structures, will understand the algorithmic viewpoint on the example of problems from different parts of mathematics.
4	Requirements for Participation recommended: Analysis, Linear Algebra
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) • Module Examination (Study Examination, Special Form, Passed / Not Passed) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.
6	Requirements on the Award of Credit Points Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
 Usability of the Module

 B.Sc. Mathematik, LaG Mathematik

 Literature

 M. Aigner, Diskrete Mathematik, 5. Auflage, Vieweg, 2003.
 T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein: Introduction to algorithms, 2. Auflage, BT, 2001.
 B. Korte, J. Vygen: Combinatorial Optimization, Springer 2012.
 J. Matoušek, J. Nešetril, Diskrete Mathematik. Eine Entdeckungsreise, Springer, 2002.

 Comment recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mod	lule na	me									
	Logi	c and F	oundat	ions							
no. 04-1			Points 3 CP	Workload	90 h	Self	- study 60 h	Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German							on respons . Dr. rer. na			odule	
1	Courses of the Module										
	Course no. Cours		Course	e name	me		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)144-vu	Logic ar	nd Foundation	ıs		0		Lectur	re	2
2	Study Content Elementary logic: propositional logic and first order logic; syntax, semantics and deductive calculi. Basic axiomatic set theory; set-theoretic construction of basic mathematical entities; ordinal and cardinal numbers. Computability, decidability and recursive enumerability based on a simple model of computation.										
3	Learni	ng Outo	comes								
	formale formale	en Syste en Syste	emen un em umge	tehen einfac d können au ehen. sch die Mode	ıf elen	nenta	rem Niveau	mit Bew	eisen	in einen	

Begriffsbildungen, Konstruktionen und Beweise im Rahmen der Mengenlehre nachvollziehen. Sie kennen die Bedeutung der fundamentalen Konzepte aus klassischer Logik und Berechenbarkeitstheorie für Grundlagenfragen der Mathematik. Nach dem erfolgreichen Besuch der Veranstaltung können die Studierenden z.B. zu Fragen der folgenden Art informiert Stellung nehmen: "Was ist eine wahre Aussage?", "Was ist ein Beweis?", "Wo liegt der Unterschied zwischen Mengen und Klassen?", "Wie misst man verschiedene Grade der Unendlichkeit?", "In welchem Sinne ist mathematische Erkenntnis sicher?", "Kann man jede wahre mathematische Aussage beweisen?" **Requirements for Participation** allgemeines mathematisches Grundwissen aus dem 1. Fachsemester Form of Examination Final Module Examination: Module Examination (Study Examination, Study Examination, Passed / Not Passed) **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed) Usability of the Module B.Sc. Mathematik, Wahlpflichtbereich Ü Literature (Exemplarisch) Forster, T.: Logic, Induction and Sets. CUP, 234pp., 2003 Kay, R.: The Mathematics of Logic. CUP, 204pp., 2007 Schindler, R.: Logische Grundlagen der Mathematik. Springer, 203pp., 2009.

10 Comment

5

Module na	Module name										
Logic and Foundations											
Module no.	Credit Points	Workload		Self-study	Duration	Frequency					
04-10- 0021/en	3 CP		90 h	60 h	1 Semester	Every 2. semester					

Lan	guage of Instru	ıction	Person responsible for the Module								
Eng			Prof. Dr. rer. nat. Martin Otto								
1	Course no.	e Module Course name		Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0145-vl	Logic and Foundations		0	Lecture	2					
2	Study Content Elementary logic: propositional logic and first order logic; syntax, semantics and deductive calculi. Basic axiomatic set theory; set-theoretic construction of basic mathematical entities; ordinal and cardinal numbers. Computability, decidability and recursive enumerability based on a simple model of computation.										
3	Learning Outcomes Die Studierenden verstehen einfache Formalisierungen mathematischer Aussagen in formalen Systemen und können auf elementarem Niveau mit Beweisen in einem formalen System umgehen. Sie können exemplarisch die Modellierung allgemeiner mathematischer Begriffsbildungen, Konstruktionen und Beweise im Rahmen der Mengenlehre nachvollziehen. Sie kennen die Bedeutung der fundamentalen Konzepte aus klassischer Logik und Berechenbarkeitstheorie für Grundlagenfragen der Mathematik. Nach dem erfolgreichen Besuch der Veranstaltung können die Studierenden z.B. zu Fragen der folgenden Art informiert Stellung nehmen: "Was ist eine wahre Aussage?", "Was ist ein Beweis?", "Wo liegt der Unterschied zwischen Mengen und Klassen?", "Wie misst man verschiedene Grade der Unendlichkeit?", "In welchem Sinne ist mathematische Erkenntnis sicher?", "Kann man jede wahre mathematische Aussage beweisen?"										
4	_	s for Participation athematisches Grundwisse	en au	s dem 1. Fachseme	ster						
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed)										
6	Requirements	on the Award of Credit	Poin	ts							
7		Examination: e Examination (Study Exa / Not Passed)	amina	ntion, Study Examin	ation, Weight	: 100%,					

8	Usability of the Module Wahlpflicht Ü-Bereich.
9	Literature
	(Exemplarisch) Forster, T.: Logic, Induction and Sets. CUP, 234pp., 2003
	Kay, R.: The Mathematics of Logic. CUP, 204pp., 2007
	Schindler, R.: Logische Grundlagen der Mathematik. Springer, 203pp., 2009.
10	Comment

Mod	lule na	me								
	Matl	nematio	cs in Co	ntext (Lehramt)					
Module no. 04-10- 0022/de		Credit Points 5 CP		Workload 150 h		- study 120 h	Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German						son respons f. Dr. rer. na				
1	Course no. Co			le e name		Workload (CP)		Form of Teaching		Contact Hours per
	04-00-0016-vl Mathematics in Context					0		Lecture		Week
2	O4-00-0016-vl Mathematics in Context O Lecture 2									

3 Learning Outcomes

Die Studierenden sind in der Lage, anhand konkreter mathematischer Inhalte Mathematik in ihren Wechselwirkungen zu Kultur und Gesellschaft zu beschreiben, die Rolle der Mathematik in ihren verschiedenen Kontexten zu beurteilen und mit ihrem Hintergrundwissen den Schulunterricht zu bereichern. Sie sind in der Lage, das Fach Mathematik in Schule und Öffentlichkeit angemessen zu vertreten

4 Requirements for Participation

Grundvorlesungen Analysis und Lineare Algebra oder vergleichbare Vorkenntnisse

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, Study Examination, Passed / Not Passed)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Fachwissenschaftliche Ergänzung

9 Literature

Victor Katz: A History of Mathematics. Harper Collins, 1993.

- C. Boyer: A History of Mathematics. John Wiley, 1968ff.
- C. C. Gillispie: Dictionary of Scientific Biography. Charles Scribner's Sons, 1970 1991.
- P. J. Davies, R. Hersh: Erfahrung Mathematik. Birkhäuser, 1994. M. Kline: Mathematical Thought fromAncient to Modern Times. Oxford University Press, 1972.
- H. Wußing: 6000 Jahre Mathematik. Springer, 2008.

10 Comment

<u>vioa</u>	uie De	scriptio	<u>on</u>							
Mod	dule na	me								
	Matl	nematio	cs in Co	ntext						
no. 04-1	Module no. Cre 04-10- 0023/de		Points 3 CP	Workload 90 h	Self-study 60 h		Duration 1 Semester		Frequency Every 2. semester	
	Language of Instruction German				Pers	on respons	ible for	the M	odule	
1	Course	es of the	e Modu	le	•					
	Course no. Course name		e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0	016-vl	Mathem	natics in Context		0		Lectur	re	2
	-Numb -Irratio -Infinit -Infinit	ers from nal num y from 2 ely sma	antiqu nbers, Fi Zenon to	of mathematics; ity to modern time ibonacci numbers, c Cantor; ities, measure theo rersus university m	cont	nd non-stan	·	alysis;		
3	Learning Outcomes Die Studierenden sind in der Lage, anhand konkreter mathematischer Inhalte Mathematik in ihren Wechselwirkungen zu Kultur und Gesellschaft zu beschreiben, die Rolle der Mathematik in ihren verschiedenen Kontexten zu beurteilen und das Fach Mathematik in Beruf und Öffentlichkeit angemessen zu vertreten.									
4	_	ements is und L		rticipation Algebra						
5		of Exam Iodule E								

	Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik, Wahlpflichtbereich Ü
9	 Literature Victor Katz: A History of Mathematics. Harper Collins, 1993. C. Boyer: A History of Mathematics. John Wiley, 1968ff. C. C. Gillispie: Dictionary of Scientific Biography. Charles Scribner's Sons, 1970 - 1991. P. J. Davies, R. Hersh: Erfahrung Mathematik. Birkhäuser, 1994. M. Kline: Mathematical Thought from Ancient to Modern Times. Oxford University Press, 1972. H. Wußing: 6000 Jahre Mathematik. Springer, 2008.
10	Comment Verantwortlich: NF Kümmerer

Mo	Module name										
	Logic and Foundations										
Module no. Credit Points Workload 04-10- 5 CP 150 h					study 105 h	Duratio 1 Semes		Frequency Every 4. semester			
	guage man	of Instru	action			on respons . Dr. phil. na					
1	Cours	ses of the	e Modu	le							
	Course no. Course name			Workload	(CP)	Forn Teac	_	Contact Hours			

					per Week							
	04-00-0144-vu	Logic and Foundations (for Teaching Degrees)	0	Lecture and Exercise	3							
2	Elementary log deductive calc mathematical	Study Content Elementary logic: propositional logic and first order logic; syntax, semantics and deductive calculi. Basic axiomatic set theory; set-theoretic construction of basic mathematical entities; ordinal and cardinal numbers. Computability, decidability and recursive enumerability based on a simple model of computation										
3	and can - at ar of examples - f proofs within to concepts of clamathematics. After the succequestions such "What is a true "What is a proof" "What is the different the calibre "In what sense	rstand simple formalisations in elementary level - handle prollow the modelling of generals the framework of set theory. It is a logic and computabilities are completed as: 2 proposition?"	roofs in a formal mathemate. They know the student see the student see the student sees?" I asses?" I asses?" I asses?" I certain?"	mal system. They can - cical concepts, construct the relevance of the func foundational issues of	by means tions and damental							
4	-	s for Participation : basic mathematical knowle	dge from the	first semester								
5	Studienleistun		· •									
6	Requirements Passing the Stu	s on the Award of Credit Poudienleistung	oints									
7	Grading Final Module I Modul Not Pa	le Examination (Study Exam	ination, Spec	ial Form, Weight: 100%	o, Passed /							
8	Usability of the B.Sc. Mathema	ne Module atik, LaG Mathematik										

9		Literature
		(examples include) Forster, T.: Logic, Induction and Sets. CUP, 234pp., 2003 Kay, R.: The Mathematics of Logic. CUP, 204pp., 2007 Schindler, R.: Logische Grundlagen der Mathematik. Springer, 203pp., 2009
1	0	Comment recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mod	Module name									
	Pros	eminar	1							
Mod no. 04-1		Credit Points 3 CP		Workload 90 h	Self	5-study 60 h	Duration 1 Semester		Frequency Every 2. semester	
Lan ; Geri		of Instru	action			son respons liendekan*ii				
1			le e name	Workload		(CP)	Form of Teaching		Contact Hours per Week	
	04-00-0	0047-ps	Prosem	inar		0		Proseminar		2
	A simple topic is assigned to individual students or to small groups of students. The subject matter may vary with the instructor's choice of a general theme. The seminar may have a project format. Each participant gives a one hour presentation to the seminar. Students give feedback on the methods of presentation employed by the speaker. Every student compiles his or her talk into a written paper.									
3	Learning Outcomes Students are able to - perform literature research - give a clear presentation of a mathematical topic - give a suitable written presentation of said topic - analyze and discuss other's talks with respect to content and method of presentation									
4	_			rticipation is and Linear Alge	bra					
5	_	of Exam Module I								

	Module Examination (Study Examination, Special Form, Passed / Not Passed)
	Studienleistung: Oral presentation, written expose, active participation in the discussion about the other oral presentations.
6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik, M. Ed.
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 2

Mod	Module name										
	Proseminar										
Module no. 04-10-0025/en		Credit Points Workload 90		Se) h	e lf-study 60 h	Duration 1 Semester		Frequency Every 2. semester			
Lan Engl	guage c lish	of Instru	ıction			Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Courses of the Module										
	Course no. Course name				Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0	147-ps	Prosemi	inar (engl.)		0		Proser	ninar	2	
2	O4-00-0147-ps Proseminar (engl.) O Proseminar 2 Study Content A simple topic is assigned to individual students or to small groups of students. The subject matter may vary with the instructor's choice of a general theme. The seminar may have a project format. Each participant gives a one hour presentation to the seminar. Students give feedback on the methods of presentation employed by the speaker. Every student compiles his or her talk into a written paper.										

3	Learning Outcomes Students are able to - perform literature research - give a clear presentation of a mathematical topic - give a suitable written presentation of said topic - analyze and discuss other's talks with respect to content and method of presentation
4	Requirements for Participation recommended: Analysis and Linear Algebra
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral presentation, written expose, active participation in the discussion about the other oral presentations.
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 2

Module n	Module name											
Introduction to Mathematical Logic												
Module no.	Credit Points	Workload	Self-study	Duration	Frequency							
04-10- 0028/en	9 CP	270 h	180 h	1 Semester	Every 2. semester							
Language	of Instruction	•	Person responsible for the Module									

Eng	glish		Prof. Dr. phil. nat. Ulrich Kohlenbach							
1	Courses of the	e Module								
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-00-0148-vu	Introduction to Mathematic Logic	al	0	Lecture and Exercise	6				
2	compactness th	t mantics of first order logic neorem; the logical and se cursion theory; undecidable	t-the	oretical foundations	s of mathemat					
3	them in conne	comes rstand the basic concepts a ction with the classical the understand the scope of f he relevant theorems.	eoren	ns of first order logi	c and the form	nal concept				
4	Requirements for Participation recommended: solid mathematical foundations in Analysis and Linear Algebra									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) • Module Examination (Study Examination, Special Form, Passed / Not Passed) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.									
6	Passing the Fa	Requirements on the Award of Credit Points Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung								
7	Grading									

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

9 Literature

examples of useful literature:

Ebbinghaus, Flum, Thomas: Einführung in die mathematische Logik;

Shoenfield: Mathematical Logic; Cori, Lascar: Mathematical Logic;

Poizat: A Course in Model Theory, an Introduction to Contemporary Mathematical Logic;

van Dalen: Logic and Structure; lecture notes where provided

10 Comment

recommended: Mathematics: Bachelor year 3 (log), Teaching Degrees

Mod	dule na	me									
	Alge	bra									
Module no. 04-10- 0029/de		Credit Points 9 CP		Workload 270 h			Duration 1 Semester		Frequency Every 2. semester		
	guage c man	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Jan Hendrik Bruinier						
1	1 Courses of the Module										
	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per Week			
	04-00-0	0080-vu	Algebra			-			e and	6	
2	Study Content Rings, Polynomial rings, Field extensions, Galois theory, Modules										
3	Learni Studen	ng Outo ts	comes								

- understand and are able to apply the notions, methods and results treated in the course
- develop a basic level of understanding of Galois theory
- are able to recognise the treated concepts in various fields of mathematics.

4 Requirements for Participation

recommended: Introduction to Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

9 Literature

J.C. Jantzen, J. Schwermer: Algebra, Springer

S. Bosch: Algebra, Springer

S. Lang: Algebra, Springer

T.W. Hungerford: Algebra, Springer

10 Comment

recommended: Mathematics: Bachelor year 3 (alg), Teaching Degrees

Mod	lule na	me								
	Man	ifolds								
Module no. Credit Points 04-10- 5 Cl 0033/de		Points 5 CP	Workload 150 h	Self	- study 105 h		Duration 1 Semester		e ncy 2. er	
	Language of Instruction German					on respons Dr. rer. na				ckmann
1 Courses of the Module										
	Course no. Cours			e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0)132-vu	Manifol	ds		0		Lectur Exerci		3
3	Learni Studen handle	ng Outo	comes rstand t ally.	kes' Theorem		_		1		
	arises in They in and car	naturally naster th n explai	y. ne forma n how t	ntexts where the mails of differentian the Fundamental Toy dimensions.	l fori	ns				
4	_			rticipation vsis, Integrationsth	eorie	e, Gewöhnlic	he Diffe	rential	lgleichu	ngen
5		of Exam Iodule I								
	•	Modul Passed		ination (Study Exa	mina	ntion, Study	Examina	ation,	Passed ,	/ Not

	Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 0%,
	 Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module Für B.Sc.Math: Wahlpflichtbereich (B, *) Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich
9	Literature Lee: Introduction to smooth Manifolds Warner: Foundations of differentiable manifolds and Lie groups Boothby: An introduction to differentiable manifolds and Riemannian geometry
10	Comment Verantwortlich: Herr Große-Brauckmann (geo)

Mod	Module name											
	Manifolds											
Module no. 04-10- 0033/en		Credit	Points 5 CP	Workload	150 h		Self-study Duration 105 h 1 Semester		Frequency Every 2. semester			
Lang Engl	guage o			le		Person responsible for the Module Prof. Dr. rer. nat. Karsten Große-Brauckmann						
	Course no. Cours		e name		Workload (CP)		Form of Teaching		Contact Hours per Week			
	04-00-03	132-vu	Manifol	ds			0		Lectur Exerci	-	3	

2 Study Content

Differentiable manifolds, tangent bundle, submanifolds, Whitney Embedding Theorem; vector fields and Lie derivative, local flow, Frobenius Theorem; differential forms, Stokes' Theorem

3 Learning Outcomes

Students understand the coordinate-invariant description and can handle it formally.

They can illustrate contexts where the manifold description arises naturally.

They master the formalism of differential forms and can explain how the Fundamental Theorem of Calculus generalizes to arbitrary dimensions.

4 Requirements for Participation

Lineare Algebra, Analysis, Integrationstheorie, Gewöhnliche Differentialgleichungen

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

Für B.Sc.Math: Wahlpflichtbereich

Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich

9 Literature

Lee: Introduction to smooth Manifolds Warner: Foundations of differentiable manifolds and Lie groups Boothby: An introduction to differentiable manifolds and Riemannian geometry

10 Comment

Verantwortlich: Herr Große-Brauckmann (geo)

Мо	dule na		Geom	otry.							
no. 04-1	Module			Workload 150 h		-study 105 h	Duratio 1 Seme		Freque Every 2 semest	y 2.	
	guage o man	of Instru	uction			on respons Dr. rer. na				icker	
1	Course	s of the	e Modu	le							
	Course no.		Cours	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0	133-vu	Differen	itial Geometry	0		Lectur Exerci		3		
	Study Content Curves: arc length and curvature; Surface theory: first fundamental form, shape operator; principal curvatures, Gaussian and mean curvature, surfaces of revolution; possibly intrinsic geometry.										
3	After h	es and s	ttended surfaces	this module the st . They know how to able to discuss ex	to de	scribe surfac	es in ter	ms of			
4	_			rticipation s, gew. Differentia	lglei	chungen, Lir	neare Alg	gebra			
5		Iodule I	ination Examina	ition:	Erro	nination T-	obnical l	Evo	antic-	Ctondoud)	
	•		e Exam	ination (Technical) ination (Study Exa		•			-		
	Fachpr	üfung (technica	al examination): U	suall	y the exam i	s taken i	in form	n of a w	ritten test,	

except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam

is taken and communicated during the first two weeks of the lecture, based on the

prospective number of students taking the exam.

6	Requirements on the Award of Credit Points					
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) 					
8	Usability of the Module B.Sc.Math math. Wahlbereich; Master: Ergänzungsbereich					
9	Literature Bär: Elementare Differentialgeometrie Montiel, Ros: Curves and surfaces Hoschek, Lasser: Grundlagen der Geometrischen Datenverarbeitung					
10	Comment Verantwortlich: Herr Reif (geo)					

Module name										
Differential Geometry										
Module no. 04-10- 0035/en		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
1	Language of Instruction English Courses of the Module				Person responsible for the Module Prof. Dr. rer. nat. Elena Mäder-Baumdicker					
Course		e no.	Course	Course name		Workload (CP)		Form Teac		Contact Hours per Week
	04-00-0227-vu Differential		ial Geometry		0		Lecture and Exercise		3	
2	Study Content									
	curves: arc length and curvature;									

surfaces: first fundamental form, Gauß map, shape operator; principal curvatures, Gaussian and mean curvature, surfaces of revolution; perhaps intrinsic geometry; modelling: Bernstein polynomials, Bézier curves and surfaces; de Casterjau algorithm **Learning Outcomes** After having attended this module the students have developed an intuition for curvature of curves and surfaces. They know how to describe surfaces in terms of differential geometry and they are able to discuss examples of curves and surfaces. **Requirements for Participation** Analysis, gew. Differentialgleichungen, Lineare Algebra 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Module Examination (Study Examination, Study Examination, Passed / Not Passed) **Requirements on the Award of Credit Points** Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) **Usability of the Module** B.Sc.Math math. Wahlbereich; Master: Ergänzungsbereich Literature Bär: Elementare Differentialgeometrie Montiel, Ros: Curves and surfaces Hoschek, Lasser: Grundlagen der Geometrischen Datenverarbeitung Comment 10 Verantwortlich: Herr Reif (geo)

Module Description

Module name

Functional Analysis								
Module no. 04-10- 0036/de	Credit Points 9 CP	Workload 270 h		Duration 1 Semester	Frequency Every 2. semester			
	of Instruction		Person responsible for the Module					
German			Prof. Dr. rer. nat. Matthias Hieber					

1 Courses of the Module

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0069-vu	Functional Analysis	0	Lecture and Exercise	6

2 Study Content

Normed vector spaces, completion; Theorem of Hahn-Banach, Theorem of Banach-Steinhaus, Open Mapping Theorem, Closed Graph Theorem; Hilbert spaces; reflexive spaces, weak convergence; Sobolev spaces, weak solution of the Dirichlet problem; spectral properties of linear operators; compact operators on Banach spaces, spectral theorem for compact operators.

3 Learning Outcomes

Students learn to

- combine ideas from linear algebra, analysis and topology
- understand and explain basic principles of functional analysis
- explain methods from functional analysis in the context of partial differential equations

4 Requirements for Participation

recommended: Analysis, Integration Theory, Complex Analysis, Linear Algebra or comparable prerequisites acquired in mathematics courses in engineering programmes

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary

	assignments and the marking scheme will be communicated by the instructor during the first lecture.
6	Requirements on the Award of Credit Points Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung
7	 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Alt: Lineare Funktionalanalysis; Conway: A Course in Functional Analysis; Reed, Simon: Functional Analysis: Methods of Modern Mathematical Physics I; Rudin: Functional Analysis; Werner: Funktionalanalysis; Ciarlet: Functional Analysis;
10	Comment recommended: Mathematics: Bachelor year 3 (ana)

Mod	Module name												
	Partial Differential Equations I												
Module no. 04-10- 0037		Credit	Points 9 CP	Workload 27	70 h			Duration 1 Semester		Frequent Every 2 semeste	.		
		of Instru				Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber							
1	Course	es of the	e Modul	le									
	Course no.		Course	e name			Workload (CP) Form of Teaching			Contact Hours per Week			
	04-00-0)184-vu	Partial I	Differential Equa	ation	s I	0		Lectur	e and	6		

Exercise **Study Content** Classical treatment of the fundamental types (e.g. elliptic, parabolic, hyperbolic, dispersive), formulation of elliptic boundary value problems as variational problems, regularity theory, theory of Sobolev spaces, Galerkin methods, fixed point methods and nonlinear elliptic and parabolic equations **Learning Outcomes** Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of partial differental equations - are able to extend their knowledge in this field **Requirements for Participation** recommended: Functional Analysis 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** 8 B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics M.Sc. ETIT Literature L.C. Evans: Partial Differential Equations (AMS) D. Gilbarg, N.S. Trudinger: Elliptic Partial Differential Equations of Second Order (Springer) M. Renardy, R.C. Rogers: An Introduction to Partial Differential Equations (Springer)

10 Comment

recommended: Mathematics: Master (ana)

Duration 90 min, Standard)

Мо	dule na	me										
	Part	ial Diffe	erential	Equations II								
no. 04-			Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Seme		Frequency Irregular			
	nguage o					son respons						
1	Course	es of the	e Modu	le	I							
	Course no.		Cours	e name	Workload (CP)		(CP)	Forn Teac	_	Contact Hours per Week		
	04-00-0)065-vu	Partial I	Differential Equation	ns II	0		Lectur	re and ise	6		
	differe	ntial equ	uations	nce, uniqueness ar with modern meth s and lecturer.								
3	Studen - under - devel - are al	rstand a op an ac ble to ex	nd are a dvanced atend th	able to apply the n level of understaneir knowledge in tervised research in	nding his fi	g of partial d eld				the course		
4	Requirements for Participation recommended: depending on the topics covered either: - Partial Differential Equations I or: - Functional Analysis - Partial Differential Equations: Classical Methods (taught in engineering programmes)											
5	_	of Exam	ination	 [
	Final N	orm of Examination inal Module Examination:										

	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order
	Amann: Linear and Quasilinear Parabolic Problems
	Dafermos: Hyperbolic Conservation Laws in Continuum Physics
	Galdi: An Introduction to Mathematical Theory of the Navier-Strokes Equations
10	Comment
	recommended: Mathematics: Master (ana)

Mod	Module name											
Elementary Partial Differential Equations												
Module no. 04-10-0039/de		Credit	Points 6 CP	Workload 180 ł		Self-study Duration 120 h 1 Semester		Frequency Every 2. semester				
Geri					Person responsible for the Module Prof. Dr. rer. nat. Jens Lang							
1	Course no. Course name			Workload	(CP)	Form Teac	_	Contact Hours per Week				
	04-00-0153-vu Elementary Partial Different		ıtial	0		Lectur Exerci	-	4				

2 Study Content

classification of partial differential equations, method of characteristics, explicit representations of solutions of the wave equation and the heat equation, physical interpretation; fundamental solutions and reen's function for elliptic differential equations, maximal principle; explicit solutions in terms of Fourier series in special dommains

3 Learning Outcomes

Nach dem Besuch des Moduls k#246;nnen die Studierenden

- die Grundtypen linearer partieller Differentialgleichungen mit klassischenund expliziten L#246;sungsmethoden untersuchen
- Mathematische Modelle zur Behandlung grundlegender naturwissenschaftlicherund technischer Problemstellungen aufstellen und analysieren

4 Requirements for Participation

Module: Analysis und Lineare Algebra, gewöhnliche Differentialgleichungen,Integration

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Study Examination, Passed / Not Passed)
- Module Examination (Technical Examination, Technical Examination, Standard)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)

8 Usability of the Module

Für B.Sc.CE: Pflicht Für B.Sc.Math, B.Sc.MCS: math. Wahlbereich (B) FürB.Sc.WiMa, B.Sc.ME: math. Wahlbereich Für M.Sc.Math, M.Sc.WiMa:Ergänzungsbereich auch in den Studiengängen der Fachbereiche Physik,Mechanik, Chemie, Maschinenbau, Bauingenieurwesen, Elektotechnik undInformationstechnik

9 Literature

John: Partial Differential Equations Jost: Partielle Differentialgleichungen Strauss: Partielle Differentialgleichungen

Sauvigny: Partielle Differentialgleichungen der Geometrie und Physik. Band1:

Grundlagen und Integraldarstellungen

10	Comment

Mo	dule na	me										
	Intro	oductio	n to Op	timization	1							
no. 04-	dule 10- 0/de	Credit	Points 9 CP	Workload 270 h	Self	- study 180 h	Duration 1 Semester		Frequency Every 2. semester			
	guage o	of Instru	uction		Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch							
1	Course	es of the	e Modu	le	•							
			e name		Workload (CP)		Form Teac		Contact Hours per Week			
	04-00-0	0023-vu	Introdu	ction to Optimizatio	n	0		Lectur Exerci	-	6		
3	-	atic optii		1								
	- are p	roficient amiliar v	vith the	mality and duality basics of the theor l methods for the	ry of	polyedra an	d convex	x funct		zation		
	proble	ms. ble to so		model application			-		-			
4	_			rticipation is, Linear Algebra								
5		of Exam Module I Modul	Examina		ımina	ation, Specia	l Form,	Passe	d / Not	Passed)		

 Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

M.Sc. ETIT

9 Literature

Chvatal: Linear Programming

Geiger, Kanzow: Theorie und Numerik restringierter Optimierungsaufgaben;

Jarre, Stoer: Optimierung Nocedal; Wright: Numerical Optimization;

Schrijver: Theory of Linear and Integer Programming;

Ziegler: Lectures on Polytopes

10 Comment

recommended: Mathematics: Bachelor year 3 (opt), Teaching Degrees

Mod	lule na	me									
	Intro	ductio	n to Op	timization							
Mod no. 04-1		O- 9 CP O/en		Workload 270 h	Self	-study 180 h	Duratio 1 Semes		Freque Every 2 semest	2.	
Lang Engl	guage o	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch						
1		es of the	e Modul	le							
	Course no. Course name		e name		Workload	(CP)	Form Teac	_	Contact Hours per Week		
	04-00-0023-vu Introduction to Optimizati				n	0		Lectur Exerci		6	
	Study Content convex sets and functions; introduction to the theory of polyhedra; theory of optimality and duality in linear optimization; simplex method for the solution of linear optimization problems; polynomial complexity of linear optimization; procedure for problems of quadratic optimization										
3	Nach d Lineare Polyede grundle Optimi	en Optir ertheori egender erungsp	uch des nierung e und d numer problem	Moduls - beherrsc und können sie ar er Theorie konvex ischen Lösungsver e - können sie line ellungen modellie	iwen er Fu fahre are u	den - sind si inktionen ve en für lineare nd quadratis	e mit de rtraut - l e und qu	n Grui kenner adrati	ndlagen 1 sie die sche	der	
4	_			rticipation Lineare Algebra							
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard) • Module Examination (Study Examination, Study Examination, Passed / Not Passed)										
6	Requir	ements	on the	Award of Credit	Poin	ts					

7	Grading Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
	 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik
9	Literature Chvatal: Linear Programming Geiger; Kanzow: Theorie und Numerik restringierter Optimierungsaufgaben; Jarre, Stoer: Optimierung Nocedal; Wright: Numerical Optimization; Schrijver: Theory of Linear and Integer Programming; Ziegler: Lectures on Polytopes
10	Comment

Mod	dule na	me									
	Optimization in Industry										
Module no. 04-10- 0041/de		Credit	Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester		
	guage o man	of Instru	ıction		Person responsible for the Module						
1	Course	es of the	e Modul	le							
	Course no. Course name			e name	Workload (CP)		(CP)	Form of Teaching		Contact Hours per Week	
	04-00-0)136-vu	Optimiz industry	ation in economy and		0		Lecture and Exercise		3	
2	Study	Conten	t								
	princip	mathematical modelling; introduction to the theory of two-person games; principle of duality and its applications; solving linear programming problems with many variables; solving integer valued linear programming problems;									

	statical and dynamical networking problems
3	Learning Outcomes Nach dem Besuch des Moduls - können sie praktische Problemstellungen auf der Basis von linearer und ganzzahliger Optimierung mathematisch modellieren - kennen sie Lösungsverfahren für solche Probleme (Branch and Bound, Schnittebenen, Spaltengenerierung, Heuristiken) - verstehen sie die besondere Bedeutung von Dualitätsaspekten in Spieltheorie, Netzwerktheorie und Linearer Programmierung
4	Requirements for Participation Mindestens Kenntnisse der Linearen Programmierung; Programmierkenntnisse möglichst in C++
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard) • Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module Für B.Sc.WiMa., B.Sc.ME: math. Wahlbereich (Optimierung); Für B.Sc.Math, B.Sc.MCS: C; Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich (Optimierung); Für CE: als mathematisches Wahlmodul
9	Literature Nemhauser, Wolsey: Integer and Combinatorial Optimization Ahuja, Magnanti, Orlin: Network Flows: Theory, Algorithms, and Application
10	Comment

Mod	dule na	me								
	Num	erical I	Viethoc	ls for Ordinary D	iffer	ential Equa	ations fo	or Eng	jineers	
no. 04-1	dule 10- 2/de	Credit	Points 5 CP	Workload 150 h		F- study 105 h	Duration 1 Semester		Frequency Every 2. semester	
	guage (man	of Instr	uction			son respons f. Dr. rer. na			odule	
1	Course	es of the	e Modu	le	I					
				e name		` ,		Form Teac		Contact Hours per Week
	04-10-0134-vu Numerik gewöhnlicher Differentialgleichungen - Anfangswertprobleme			itialgleichungen -		0 Le			re and se	3
3	Study Content initial value problems: one-step methods, multi-step methods; convergence analysis, notions of stability; boundary-value problems: Shooting methods, finite difference methods, stability and convergence; Learning Outcomes Students know the basic numerical solution concepts for ordinary differential equations									
				nalyze, compare, a		-		direct		quutions
4	recomi	nended	: Analys	rticipation is, Linear Algebra, similar knowledge						
5		Iodule I Modul				•			-	
	only a form of communications during	small ni f an ora inicated	umber o l exam. l t two we	the exam is taken f potential participe. The decision abouteeks of the lecture.	oants t the	i. In this case form of the	e, the exa exam is	am car taken	n be tako and	en in the

	Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.								
6	Requirements on the Award of Credit Points								
	Passing the Fachprüfung ;								
	Passing the Studienleistung is a prerequisite for taking the Fachprüfung								
7	Grading								
	Final Module Examination:								
	 Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) 								
	 Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) 								
8	Usability of the Module								
	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics								
	M.Sc. ETIT								
9	Literature								
	Deuflhard, Bornemann: Numerische Mathematik 2								
	Stoer, Bulirsch: Numerische Mathematik 2								
10	Comment								
	recommended: Mathematics: Bachelor year 3 (num)								

Mod	Module name											
	Numerical Linear Algebra											
Module no. 04-10- 0043/de		Credit	Points 5 CP	Workload	150 h	Self-study Duration 105 h 1 Semeste			Frequency Every 2. semester			
	Language of Instruction German						Person responsible for the Module Dr. rer. nat. Alf Gerisch					
1	Course	es of the	e Modul	le								
	Course no. Cours		e name		Workloa		rkload (CP)		of hing	Contact Hours per Week		
	04-00-0139-vu Numerical Linear Algebra			gebra		0		Lectur	e and	3		

	Exercise									
2	Study Content Systems of linear equations: iterative methods, singular value decomposition, eigenvalue problems.									
3	Learning Outcomes Students know about the most important numerical methods of linear algebra and they are able to explain, classify, and apply them.									
4	Requirements for Participation recommended: Linear Algebra, Introduction to Numerical Analysis or similar knowledge									
5	Form of Examination Final Module Examination:									
	Module Examination (Study Examination, Special Form, Passed / Not Passed)									
	Module Examination (Technical Examination, Technical Examination, Standard)									
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated									
	during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
	Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.									
6	Requirements on the Award of Credit Points									
	Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung									
7	Grading Final Module Examination:									
	 Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) 									
	 Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) 									
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics M.Sc. ETIT									
9	Literature									
	1									

	Trefethen/Bau: Numerical Linear Algebra, SIAM Demmel: Applied Numerical Linear Algebra, SIAM Stoer/Bulirsch: Numerische Mathematik 2, Springer
10	Comment recommended: Mathematics: Bachelor year 3 (num)

0- 3/en guage o ish Course	Credit of Instru	Points 5 CP action	Algebra Workload 150 h		- study 105 h	Duration 1 Semes		_	-		
0- 3/en guage o ish Course	of Instru	5 CP			•			_	-		
ish Cours e	es of the			Pers				Frequency Every 2. semester			
		e Modu			Person responsible for the Module Dr. rer. nat. Alf Gerisch						
Course	no.	1 Courses of the Module									
	Course no. Course		e name		Workload (CP)		Form of Teaching		Contact Hours per Week		
04-00-0	04-00-0139-vu Numerical Linear Algebra 0				Lectur Exerci		3				
Study Content Systems of linear equations: iterative methods, singular value decomposition, eigenvalue problems. Learning Outcomes Students know about the most important numerical methods of linear algebra and they are able to explain, classify, and apply them											
-			-	tion t	to Numerical	l Analysi	s or sii	milar kn	owledge		
Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are											
	Requir recomr Form (Requirements recommended: Form of Exam Final Module E Modul Modul	Requirements for Parrecommended: Linear Form of Examination Final Module Examina Module Examination Module Examination	Requirements for Participation recommended: Linear Algebra, Introduct Form of Examination Final Module Examination: • Module Examination (Study Examination)	recommended: Linear Algebra, Introduction of Form of Examination Final Module Examination: Module Examination (Study Examination (Module Examination (Technical Examination))	Requirements for Participation recommended: Linear Algebra, Introduction to Numerical Form of Examination Final Module Examination: • Module Examination (Study Examination, Special • Module Examination (Technical Examination, orange)	Requirements for Participation recommended: Linear Algebra, Introduction to Numerical Analysi Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, • Module Examination (Technical Examination, oral / written)	Requirements for Participation recommended: Linear Algebra, Introduction to Numerical Analysis or sin Form of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Passed Module Examination (Technical Examination, oral / written Examination)	Requirements for Participation recommended: Linear Algebra, Introduction to Numerical Analysis or similar known of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Passed / Not 1) Module Examination (Technical Examination, oral / written Examination)		

form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Trefethen/Bau: Numerical Linear Algebra, SIAM Demmel: Applied Numerical Linear Algebra, SIAM Stoer/Bulirsch: Numerische Mathematik 2, Springer

10 Comment

recommended: Mathematics: Bachelor year 3 (num)

Module Description

Module name **Introduction to Mathematical Modelling** Module Frequency Credit Points | Workload Self-study Duration no. Every 4. 90 h 1 Semester 04-10-5 CP 150 h semester 0044/de **Language of Instruction** Person responsible for the Module German Prof. Dr. rer. nat. Jens Lang **Courses of the Module**

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0140-vu	Introduction to Mathematical Modelling	0	Lecture and Exercise	4

2 Study Content

basic concepts, statical linear, non-linear and discrete systems, dynamical systems in one and more dimensions, systems with opponent, random.

3 Learning Outcomes

Students understand and are able to apply the basic techniques of mathematical modeling. They are aware of particular solution concepts for exemplary applications and understand the underlying mathematical structures. The students are able to apply known modeling techniques to further applications and to interprete the results.

4 Requirements for Participation

recommended: Analysis, Linear Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung (technical examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung (study examination): Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc. Mathematik, LaG Mathematik
9	Literature
	lecture notes
10	Comment
	recommended: Mathematics: Bachelor year 3, Teaching Degrees

Mod	lule naı	ne									
	Prob	ability	Theory	7							
Module Credit Po 04-10- 0045/de		Points 9 CP	Workload 270 h		-study 180 h	Duration 1 Semes		Freque Every 2 semeste			
						Person responsible for the Module Prof. Dr. rer. nat. Michael Kohler					
1	Course	s of the	Modu	le	•						
	Course no. Course name			e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0	141-vu	Probabi	lity Theory		0		Lecture and Exercise		6	
2	Measur converg	gence, c itions, n	etical fo haracte	undations, theory ristic functions, sto ales in discrete tim	ochas	tic independ	dence, 0-	1-laws	s, condit	ional	
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of probability theory - are able to recognise the treated concepts in various fields of mathematics.										
4	-			rticipation is, Integration The	eory,	Introduction	ı to Stocl	hastics	3		

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

9 Literature

Bauer: Probability Theory

Billingsley: Probability and Measure Elstrodt: Maß-und Integrationstheorie Gänssler, Stute: Wahrscheinlichkeitstheorie

Klenke: Wahrscheinlichkeitstheorie

10 Comment

recommended: recommended: Mathematics: Bachelor year 3 (sto), Teaching Degrees

Mod	dule na	mo								
MO		ability	Theory	,						
no. 04-1	dule	_		Workload 270 h		- study 180 h	Duratio 1 Seme		Freque Every 2 semeste	2.
Lan Eng		of Instri	ıction			son respons				
1	1	es of the	e Modu	le	ı					
			e name	name		Workload (CP)		n of hing	Contact Hours per Week	
	04-00-0071-vu Probability Theory					0		Lectui Exerci	-	6
	Study Content Measure theoretical foundations, theory of integration, random variables, concepts of convergence, characteristic functions, stochastic independence, 0-1-laws, conditional expectations, martingales in discrete time, limit theorems: law of large numbers, central limit theorem.									
3	Studen - under - devel	rstand a	nd are a	able to apply the n of understanding the treated conce	of pr	obability the	eory			he course
4				rticipation is, Integration The	eory,	Introductior	ı to Stoc	hastics	5	
5		of Exam Module I								
	•			ination (Technical) in, Standard)	Exar	nination, ora	al / writt	ten Ex	aminatio	on,
	•	Modul	e Exami	ination (Study Exa	ımina	ation, Specia	l Form,	Passe	d / Not I	Passed)
	only a form o	small n	umber o l exam.	the exam is taken f potential particip The decision abou	oants	. In this case	e, the exa	am car	n be take	
	only a form o	small ni f an ora	umber o l exam.	f potential particip	oants	. In this case	e, the exa	am car	n be take	

during the first two weeks of the lecture, based on the prospective number of students

taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

9 Literature

Bauer: Probability Theory

Billingsley: Probability and Measure Elstrodt: Maß-und Integrationstheorie Gänssler, Stute: Wahrscheinlichkeitstheorie

Klenke: Wahrscheinlichkeitstheorie

10 Comment

recommended: Mathematics: Bachelor year 3 (sto), Teaching Degrees

Module Description

Module name **Introduction to Mathematical Finance** Module Frequency Credit Points | Workload Self-study Duration no. Every 2. 04-10-5 CP 150 h 105 h 1 Semester semester 0047/de **Language of Instruction** Person responsible for the Module German Prof. Dr. rer. nat. Michael Kohler **Courses of the Module** Course no. Course name Workload (CP) Form of Contact Hours

			Teaching	per Week
	04-00-0084-vu	Introduction to Mathematical Finance	Lecture and Exercise	3
2	Study Conten	t		

Optionen, Arbitragegrenzen, Ein-Perioden-Modell, stochastische Integrale, Gleichung des Aktienpreises, Ito-Formel, Black-Scholes-Formel, Bewertung von Optionen mit numerischen Verfahren.

3 **Learning Outcomes**

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop a basic level of understanding of financial mathematics

Requirements for Participation

recommended: Introduction to Stochastics, Probability Theory

Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, Technical Examination, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

Requirements on the Award of Credit Points

Passing the Fachprüfung

Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)

8 Usability of the Module
B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature
Bingham, Kiesel: Risk-Neutral Valuation;
Elliott, Kopp: Mathematics of Financial Markets;
Irle: Finanzmathematik;
Musiela, Rutkowski: Martingale Methods in Financial Modelling;
Pliska: Introduction to Mathematical Finance;
Shreve: Stochastic Calculus for Finance I (Discrete Time Models)

recommended: Mathematics: Bachelor year 3 (sto)

Mod	Module name										
	Life l	Insuran	ce Mat	thematics							
Module no. Credi 04-10- 0049/de		Credit	Points Workload 5 CP 150 h			f-study Duration 105 h 1 Semes		-		•	
	guage o	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Frank Aurzada						
1	1 Courses of the Module										
	Course no. Cours		Cours	e name	Workload		(CP)	Form of Teaching		Contact Hours per Week	
	04-00-0162-vu Life Insurance Mathematics					Lecture and Exercise		3			
2	Study Content O. Basic principles of insurance contracts 1. Elementary financial mathematics 2. Functions of bounded variation, Lebesgue-Stieltjes integral 3. Equivalence principle, actuarial reserve 4. Basic notions of life insurance mathematics, examples 5. Thiele's integral equation 6. Conditional expectations, martingales 7. Hattendorf's theorem Potential societal implications will be addressed in the lecture.										
3	- under		asic pri	nciples of insuranc		e mathemat	ics				

- be able to compute a premium flow
- be able to design new types of insurance contracts and compute the respective premium flow
- basic properties of martingles

4 Requirements for Participation

Recommended: Einführung in die Stochastik \

Maß- und Integrationstheorie \

Concurrent attendance of the lectur Probability Theory

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated by the instructor during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc.Math, B.Sc.WiMa: Wahlpflichtbereich

Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich

9 Literature

Klaus D. Schmidt: Versicherungsmathematik. Springer.

10 Comment

Module Description

Module name

Non-Academic Internship

Mod	lule									
no. 04-1	0	Credit	Points 5 CP	Workload 150 h		-study	Duratio 1 Semes		Frequency Every semester	
	1/de		J Gr	130 11		130 11	1 Semes	SICI	Every s	Semester
		of Instru	ıction			son respons				
Geri		es of the	Modu		Stuc	liendekan*i	n des Fac	hbere	ichs 04	
1	Course no. Course name Study Content							Form Teac		Contact Hours per Week
2	Study Content volunteering or internship in a company or a extra-academic institution in a location reflecting the potential future work environment of a mathematics student.									
3	Learning Outcomes The students experience a realistic working environment for mathematicians. They can work in teams and have an idea how mathematicians may work and can report on it.									
4	Requirements for Participation Students need to find and organize their internship on their own.Internships need to be suitable for mathematicians. If this is the case only for parts of the internship, ist duration needs to be proportionally greater. Suitability for mathematicians is determined by a lecturer of the department of mathematics.									
5	_	of Exam Iodule E	Examina		nmina	ation. Specia	ıl Form.	Passed	1 / Not :	Passed)
	Studie: departi	nleistun		en and oral preser			-			
6	-			Award of Credit stung (oral and w			n)			
7	Gradin Final M	Iodule I	e Exam	ntion: ination (Study Exa	amina	ntion, Specia	l Form, V	Weigh	t: 100%	, Passed /
8				ıle ly PO 2011), M.Sc	. Mat	hematik, M.	Sc. Math	emati	cs (only	PO 2011
9	Literat	ure								

10	Comment 4 weeks / 150 hours of internship recommended: Mathematics: Bachelor year 3 (only PO 2011) or Master (only PO 2011 and PO 2018)

	dule na	me								
	Proje	ect in M	lathem	atics (Bachelor)						
no. 04-2	Module no.			Workload 150 h	Self			Duration 1 Semester		n cy r
	Language of Instruction German					on respons			odule	
1	Course	es of the	e Modul	le						
	Course no. Course name Workload (CP) Form of Teaching He					Contact Hours per Week				
	A small group works on a complex problem. The formulation of the problem may be open ended; a final precise and focussed fomulation may be a part of the project. The concrete subject matter content will depend on the problem. Regular reports describe the work in progress. In conclusion, there will be a presentation in which the results are described and discussed. A report in writing, preferably in LATEX, will record and document the results of the project.									
3	Learning Outcomes Students are able to find solution strategies for a given complex problem. They are able to split the problem into appropriate subproblems, solve them and present them to an audiance. Depending on the topic, they may also do experiments and use software.									
	audian	_		on the topic, they	may a			_		to an
4	Requir	ce. Depo	ending of	on the topic, they recticipation	may a			_		to an

6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 instead of a seminar. May be the starting point of a bachelor thesis.

Mod	lule na	me								
	Proje	ect in M	athem	atics (Bachelor)						
Module no. Credit 04-10- 0053/en		Points 5 CP	Workload 150 h		-study 150 h	Duration 1 Semester		Frequency Irregular		
Language of InstructionPerson responsible for the ModuleEnglishProf. Dr. rer. nat. Martin Kiehl										
1	Course	es of the	e Modu	le						
	Course no.		Cours	e name	Workload (CP)		Form of Teaching		Contact Hours per Week	
2	Study Content A small group works on a complex problem. The formulation of the problem may be open ended; a final precise and focussed fomulation may be a part of the project. The concrete subject matter content will depend on the problem. Regular reports describe the work in progress. In conclusion, there will be a presentation in which the results are described and discussed. A report in writing, preferably in LATEX, will record and document the results of the project.									
3	Learning Outcomes Students are able to find solution strategies for a given complex problem. They are able to split the problem into appropriate subproblems, solve them and present them to an									

	audiance. Depending on the topic, they may also do experiments and use software.
4	Requirements for Participation recommended: depending on topic
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Giving an oral presentation about the results of the project.
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 instead of a seminar. May be the starting point of a bachelor thesis.

Mod	Module name										
	Applied Proof Theory										
Module no. Credit Points		Workload		Self-study		Duration		Frequency			
04-1 005	10- 8/en	9 CP			270 h	180 h		1 Semester		Irregular	
Lan Engl	0	of Instru	ıction				on respons . Dr. phil. na				
1	Course	es of the	e Modul	le		•					
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per Week

	04-00-0166-vu Applied Proof Theory 0 Lecture and Exercise 6
2	Study Content This course develops the major techniques of applied proof theory, namely so-called proof interpretations together with applications to various areas of mathematics such as approximation theory, nonlinear analysis and ergodic theory. These applications are concerned with the extraction of effective bounds and new qualitative uniformity results from prima facie ineffective proofs. The main techniques studied are: Herbrand theory, no-counterexample interpretation (Kreisel), modified realizability (Kreisel), Gödel's functional ('Dialectica') interpretation, negative translation (Gödel), functional interpretation of full analysis (Spector), monotone interpretations and their extensions to systems based on classes of abstract (nonseparable) metric, hyperbolic and normed spaces
3	Learning Outcomes Students 1) understand and are able to use formal calculi of intuitionistic logic, arithmetic and analysis (also in higher types); 2) have command of the treated proof interpretations (modified realizability, functional interpretation, monotone functional interpretation); 3) understand the logical metatheorems presented (both for specific polish spaces as well as for general classes of abstract spaces) and can assess their scope of applicability; 4) can apply such metatheorems on their own (e.g. in the context of a master thesis) to suitable noneffective proofs in analysis (approximation theory, fixed point theory, ergodic theory).
4	Requirements for Participation recommended: Introduction to Mathematical Logic, Introduction to Computability Theory (useful)
5	 Form of Examination Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination:

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Kohlenbach, U.: Applied Proof Theory: Proof Interpretations and Their Use in Mathematics. Springer Monograph in Mathematics, xx+536pp., 2008
10	Comment recommended: Mathematics: Master (log) Due to content overlap, this course cannot be combined with Basic Applied Proof Theory oder Advanced Applied Proof Theory eingebracht werden.

Mod	lule na	me								
	Intro	ductio	n to Co	mputability The	ory					
		Points 5 CP	Workload 150 h	Vorkload Self-		Duration 1 Semester		Frequency Irregular		
	guage o	of Instru	action			son respons . Dr. phil. na				
1	Course	es of the	e Modu	le		1				
	Course no. Co		Course	e name	Workload ((CP)	Form of Teaching		Contact Hours per Week
	04-00-0)167-vu	Introdu Theory	ction to Computabil	ity	0	Lectur Exerci		3	
2	Study Content This course gives a brief introduction to classical recursion (computability) theory culminating in the solution of Post's problem by the priority method (Friedberg/Muchnik). Table of contents: the basic machine, definition of recursive functions, codes and indices, Kleene normal form theorem, Kleene recursion theorem, Church's thesis, relative recursion, arithmetical hierarchy, recursively enumerable relations, Turing degrees, solution of Post's problem, computable functionals.									
3	Studen 1) und	erstand	and car	apply the basic the			cal comp	utabil	ity theo	ry (Kleene

- 2) can classify arithmetically defined predicates according to their complexity in the arithmetical hierarchy;
- 3) understand the various concepts of reducibility and their relation (many-one, truth-table, Turing);
- 4) have a basic understanding of the priority method due to Friedberg and Muchnik and are able to learn on their own from additional literature.

4 Requirements for Participation

recommended: Introduction to Computability Theory Alternatively: Logic as taught in CS programmes

5 Form of Examination

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Shoenfield, Joseph R.: Recursion Theory. ASL and A K Peters, 96pp., 2001. Cutland, Nigel J.: Computability. Cambridge University Press 1980.

10 Comment

recommended: Mathematics: Master (log)

Module Description

Module name

Modal Logics

no. 04-1	Module no. Credit Points 04-10- 5 CP 0061/en		Workload 150 h		f-study Dura 105 h 1 Sen		-		-	
Lang Engl		of Instru	action			on respons . Dr. rer. na			odule	
1										
	Course no. Course name		e name	e		Workload (CP)		n of hing	Contact Hours per Week	
	04-00-0)170-vu	Modal I	Logics		0		Lectur Exerci		3
2	Kripke modal model	logic as theory o	ics for n a fragn of moda	nodal logics; bisim nent of first-order l logics; relevant e modal μ-calculus,	logic; extens	classical co sions of basi	rrespond	lence t	heory;	finite
3	Learning Outcomes Students understand and are able to apply the essential model-theoretic notions relevant for the study of modal logics as treated in the course. They have developed an advanced level of understanding of several systems of modal logics in terms of expressiveness, axiomatisability and algorithmic properties, which enables them to extend their knowledge in this field and allows them to conduct related research under supervision.								advanced ness, r	
4	recomi	nended	: Introd	rticipation uction to Mathem taught in CS pros		•				
5	_	of Exam Iodule I								
	•			ination (Technica in, Standard)	l Exar	nination, or	al / writt	ten Exa	aminati	on,
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	-	ements		Award of Credit	Poin	ts				
7	Gradi r Final M	i g Iodule I	Examina	ntion:						

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature Blackburn, de Rijke, Venema: Modal Logic Goranko, Otto: Model Theory of Modal Logics, in: Handbook of Modal Logic, Blackburn, van Benthem, Wolter (eds)
10	Comment recommended: Mathematics: Master (log)

Mod	lule na	me								
	Num	erical A	Analysi	s of Hyperbolic E	Equa ⁻	tions				
		it Points Workload 5 CP 150 h			3		Duration 1 Semester		e ncy ar	
Language of Instruction German and English Person responsible for the Modu Prof. Dr. rer. nat. Jens Lang							odule			
1	Course no. Course name					Workload (CP) Form Teach			_	Contact Hours per Week
	04-00-0	156-vu		cal Analysis of olic Equations					e and se	3
2	Hyperb	-	uations:	Classical solutions lumne, higher ord	-					ion,
3	Learning Outcomes Students know about the basic numerical solution strategies for hyperbolic differential equations. They are able to explain, analyse, implement, and compare these methods.									
4	Requirements for Participation recommended: Numerical Analysis of Ordinary Differential Equations									
5		-	ination Examina							

• Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

LeVeque: Finite Volume Methods for Hyperbolic Problems, Cambridge University Press 2003;

Großmann/Roos: Numerik Partieller Differentialgleichungen, Teubner 2005.

10 Comment

recommended: Mathematics: Master (num)

Module name												
Holding Exercise Classes												
Module no. 04-10- 0077		Credit	Points 3 CP	Workload 90) h	Self-study 90 h		Duration 1 Semester		Frequency Every semester		
	Language of Instruction German and English						Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	1 Courses of the Module											
	Course no. Course		e name			Workload (CP)		Form Teac		Contact Hours per Week		
	04-00-0	049-ku	Holding	Exercise Classes			0		Course	e	0	

2 Study Content

Participation in tutor training incl. trainers visiting the trainee's classes, Preparing and tutoring an exercise class, Grading of written exercises, Participation in preparatory meetings

3 Learning Outcomes

Students learn to

- explain mathematics and recognise typical problems in understanding mathematics
- talk freely in front of larger classes
- handle questions spontaneously and moderating classes
- learn new mathematical material on their own

4 Requirements for Participation

mathematical and didactical prerequisites, depending on the class held

5 Form of Examination

Final Module Examination:

• Module Examination (Study Examination, Special Form, Passed / Not Passed)

Studienleistung: Active participation in the programme for the training of student instructors, including visits to the exercise class during the semester; successfully delivering an exercise class, including active participation at the preparation sessions. Positive evaluation of the personal performance by the lecturer. A short report may be required.

6 Requirements on the Award of Credit Points

Passing the Studienleistung

7 Grading

Final Module Examination:

 Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

10 Comment

recommended: Mathematics: Master

Module name										
Project in Mathematics (Master)										
Mod no. 04-1 008	L O -	Credit Points 5 CP		Workload 150 h	Self-study 150 h		Duration 1 Semester		Frequency Irregular	
	Language of Instruction German and English			Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	1 Courses of the Module									
	Course no		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0080-ku Project in Mathematics (Mathematics (Mathem				ster)	0	0 F		t	0
	A small group works on a complex problem. The formulation of the problem may be open ended; a final precise and focussed fomulation may be a part of the project. The concrete subject matter content will depend on the problem. Regular reports describe the work in progress. In conclusion, there will be a presentation in which the results are described and discussed. A report in writing, preferably in LATEX, will record and document the results of the project.									
3	Learning Outcomes Students are able to find solution strategies for a given complex problem. They are able to split the problem into appropriate subproblems, solve them and present them to an audience. Depending on the topic, they may also use software.									
4	Requirements for Participation recommended: depending on topic									
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Giving an oral presentation about the results of the project.									
6	Requirements on the Award of Credit Points Passing the Studienleistung									
7	Grading Final Module Examination:									

	Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Master

Module name												
Teaching and Learning Mathematics												
Module no. 04-10-0086/de		Credit Points 6 CP		Workload 180 h	Self-study 120		Duration 1 Semester		Frequency Every 2. semester			
Language of Instruction German					Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger							
1	Course	Courses of the Module										
	Course no.		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week		
			Teaching and Learning of Mathematics			0		Lecture and Exercise		4		
2	Study Content Models of teaching Mathematics, theory of tasks, types of learning goals, methods for long-term development of competences											
3	Learning Outcomes The students are able to use different theoretical concepts to describe and prepare typical math-teaching and learning situations for heterogeneous learning groups; to select and develop tasks											
4	Requirements for Participation recommended: Analysis and Linear Algebra or equivalent											
5	Form of Examination Final Module Examination:											

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik

9 Literature

lecture notes

Bruder, R., Leuders, T., Büchter, A. (2008): Mathematikunterricht entwickeln, Cornelsen Verlag

Scriptor; Bruder, R., Hefendehl-Hebeker, L., Schmidt-Thieme, B. Weigand, H.-G. (Hrsg.) (2015), Handbuch der Mathematikdidaktik. Springer Berlin Heidelberg

10 Comment

recommended: Mathematics: Bachelor year 2

Module Description

Module name

Teaching and Learning Mathematics (LaG)

Mod no. 04-1 008		Credit	Points 10 CP	Workload 300 h	Self	- study 240 h	Duratio 2 Seme		Frequency Every 2. semester		
Lan Geri		of Instru	action		Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
1	Course	es of the	e Modu	le							
	Course		Course name			Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0)107-ps		zed didactics for aduates		0		Proser	ninar	0	
	04-00-0179-vu Teaching and Learning of Mathematics					0		Lectur	re .	4	
	04-10-0322-vl Variety of mathematical ta (online)					0		Lectur	re	0	
2	Study Content Siehe Teilmodule "Lehren und Lernen von Mathematik", "Mathematische Aufgabenvielfalt (online)" und "Fachdidaktisches Proseminar"										
3	Learning Outcomes Siehe Teilmodule "Lehren und Lernen von Mathematik", "Mathematische Aufgabenvielfalt (online)" und "Fachdidaktisches Proseminar"										
4	Siehe 7	Гeilmod	ule "Leh	rticipation aren und Lernen vone)" und "Fachdida		-		natisch	ne		
5		of Exam Iodule I Modul	Examina		Exar	nination, Te	chnical 1	Examiı	nation,	Standard)	
6	Requi			Award of Credit							
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)										
8	Usability of the Module Pflichtmodul für LaG.Math.										
9	Literat Siehe		ule "Leh	ıren und Lernen vo	on Ma	athematik",	"Mather	natisch	ıe		

	Aufgabenvielfalt (online)" und "Fachdidaktisches Proseminar"
10	Comment

viou	uie De	scripti	<u> </u>							
Mod	dule na	me								
	Proje	ect in N	lathem	atical Didactics						
no. 04-1	dule 10- 8/de	Credit	Points 6 CP			•		o n ester	Frequency Every 2. semester	
	Language of Instruction German					son respons . Dr. phil. na				
1	Course	es of the	e Modu	le						
				e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-00-0038-pj Subject-specific project Analysis of learning eff for mathematics				су	0		Project		0
	04-00-0)039-pj	Subject- in schoo	specific project: Alg ols	ebra	0		Projec	t	0
	04-00-0)043-pj		specific project: ns Solving		0		Project		0
	04-00-0)113-рј	Applicat	-specific project: tion-oriented natical lessons		0		Project		0
	04-00-0)292-pj	Subject-specific project: Analysis in schools			0		Project		0
2		Conten Feilmod						•		•
3		ng Out o								
4	_			rticipation agen des Lehrens 1	ınd I	Lernens von	Mathem	natik" a	lbgesch	lossen
5			ination Examina							

	Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module
	Fachdidaktisches Projekt im Wahlpflichtbereich
9	Literature
	Siehe Teilmodule
10	Comment

Mod	lule na	me								
	Geo	metry (for Tea	ching Degrees)						
Module no. C 04-10- 0091/de		Credit Points 5 CP		Workload 150 h	Self-study 90		Duration 1 Semester		Freque Every 2 semeste	
Lan ; Gerr		of Instr	ıction			son respons . Dr. rer. nat				
1 Courses of the Module										
	Course no.		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0	0110-vu	Geomet Degrees	ry (for Teaching		0			e and se	4
2	Degrees) Exercise									
3		ng Out o		nen und verstehen	die e	elementarge	ometrisc	hen G	rundbeg	riffe und

Methoden und können diese auf typische Fragestellungen anwenden. **Requirements for Participation** Linear Algebra (participation without certification of prerequisites is possible) 5 Form of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Fachprüfung: In der Regel erfolgt die Prüfung durch eine Klausur, bei geringer Teilnehmerzahl gegebenenfalls mündlich. Die Form der Prüfung wird anhand der voraussichtlichen Teilnehmerzahl in den ersten beiden Veranstaltungswochen festgelegt. Studienleistung: Sonderform (In der Regel erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.) 6 **Requirements on the Award of Credit Points** Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung 7 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** 8 Mathematics: Teaching degrees Literature I. Agricola, T. Friedrichs Elementargeometrie, Vieweg - Teubner G.A. Jennings: Modern geometry with applications, Springer 10 Comment

Mod	lule na	me									
	Pract	tical Tra	aining I	III: Mathematics	in So	chools					
Mod no. 04-1		Credit	Points 5 CP	Workload 150 h	Self	- study 120 h	Duratio 1 Seme		Freque Every 2 semest	2.	
Lan Geri	guage o man	of Instru	action		Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
1	Course	s of the	e Modu	le	•						
			e name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0044-se Practical t			ll training in schools hematics	II	0		Semin	ar	2	
2	Study Content observation, planning and reflexion of mathematics lessons as well as didactic and methodical concepts of learning environments, using didactic literature; discussion about a specialised didactic main focus. The students continue her portfolio from the practise phases I and II during the traineeship, take part in a consultation offer and write a training period report.										
3	The stu	n-basec	re able l. They a	to observe lessons are able to create l f specialised didac	essoı	n plans with					
4	Founda	ations o	f Teachi	rticipation Ing and Learning N certification of pro				se I			
5	 (participation without certification of prerequisites is possible) Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Module Examination (Study Examination, oral / written Examination, Passed / Not Passed) 										
6	_	the Fa		Award of Credit ng; passing the St			prerequ	iisite fo	or takin	g the	

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematics: Teaching degrees

9 Literature

Barzel, B., Holzäpfel, L., Leuders, T., Streit, C. (2011). Scriptor Praxis - Mathematik: Mathematik unterrichten: Planen, durchführen, reflektieren: Buch mit Kopiervorlagen. Cornelsen Verlag Scriptor.

Kratz, H. (2011). Wege zu einem kompetenzorientierten Mathematikunterricht – Ein Studien- und Praxisbuch für die Sekundarstufe. Kallmeyer – Klett, Seelze.

Meyer, H. (2004). Praxisbuch: Was ist guter Unterricht? Mit didaktischer Landkarte. Cornelsen Verlag Scriptor.

10 Comment

Verantwortlich: Frau Krüger (did)

Mo	dule na	me										
	Intr	oductio	n to Ex	cel (online)								
Module no. 04-10- 0095/de		Credit	redit Points Workload 0 h		Self-study 0 h		Duration 1 Semester		Frequency Irregular			
	i guage man	of Instru	uction		Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger							
1	Courses of the Module											
	Cours	e no.	e name		Work	load	(CP)	Forn Teac	n of ching	Contact Hours per Week		
	04-10-	0095-ku	Introdu	ction to Excel (onlin	e)	0			Course		0	
2	Basics	04-10-0095-ku Introduction to Excel (online) 0 Course 0 Study Content Basics of excel for use in math-education, diagrams and random numbers, functions and sliders, recursion and iteration, (interactive) worksheets										

3	Learning Outcomes
	The participants
	acquire knowledge about the basic usage of excel and especially about functions and
	possibilites for usage in math-eduction.
	are able to use the software in addition to standard purposes for mathematical use
	cases and in class.
4	Requirements for Participation
5	Form of Examination
	Final Module Examination:
	Module Examination (Study Examination, Special Form, Passed / Not Passed)
	Wioduic Examination (Study Examination, Special Porm, Passed / Not Passed)
6	Requirements on the Award of Credit Points
	Bestehen der Studienleistung
7	Grading
	Final Module Examination:
	M 11 F ' ' ' (0: 1 F ' ' ' C ' ' F ' M ' ' 1000/ P 1 /
	Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Note Based 1)
	Not Passed)
8	Usability of the Module
	Mathematics: Teaching degrees (only as "freiwillige zusätzliche Leistung")
9	Literature
	Moodle-Kurs online
10	Comment
10	Verantwortlich: Frau Krüger (did)
	verantivortalen. 11au 1auger (ala)

Mod	Module name											
	Mathematics I (for Computer Science)											
Module no. Credit Points 04-10- 9 CP 0118/de Work		Workload 270 h		study Duration 180 h 1 Semester			Frequency Every 2. semester					
Lan	guage (of Instru	ıction		Person responsible for the Module							
Geri	nan				Prof.	. Dr. phil. na	at. Ulrich	Kohle	enbach			
1	Courses of the Module											
	Course	e no.	Course	e name		Workload	(CP)	Form	of	Contact		

			Teaching	Hours per Week
04-00-0128-vu Mathematics I Science)	(Computer	0	Lecture and Exercise	6

2 Study Content

- sets, relations, functions, groups, basic algebraic structures
- modular arithmetic, RSA algorithm for encrypting data
- finite dimensional vector spaces, linear maps and matrices, Gauss algorithm, determinants, eigenvalues
- basics: real and complex numbers
- sequences and convergence

3 Learning Outcomes

- Beherrschung der mengentheoretischen Sprechweise
- Vertrautheit mit grundlegenden algebraischen Strukturen und Grundbegriffen
- Verständnis der grundlegenden Begriffe der linearen Algebra
- Beherrschung der grundlegenden Algorithmen der linearen Algebra
- Verständnis des Begriffs der reellen Zahlen und Beherrschung des Umgangs mit Grenzwertprozessen.

4 Requirements for Participation

none

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, oral / written Examination, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

	-
	Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module required
9	Literature lecture notes of course
10	Comment

Mod	Module name											
	Mathematics II (for Computer Science)											
Module no. 04-10- 0119/de		Credit	Points 9 CP	Workload	270 h		study 180 h	Duration 1 Semester		Frequency Every 2. semester		
`	Language of Instruction German					Person responsible for the Module Prof. Dr. phil. nat. Ulrich Kohlenbach						
1	Course	es of the	e Modul	le								
	Course no.		Course name			Workload (CP)		P) Form of Teaching		Contact Hours per Week		
	04-00-0087-vu Mathematics II (Compu Science)		nputer		0		Lectur Exerci		6			

2 Study Content

- series and power series
- standard functions
- real functions and continuity
- differential calculus, extremal values, inverse function
- exponential function and logarithm
- integration: integrals, Fundamental Theorem of Calculus, techniques of integration
- real functions of several variables
- Taylor and Fourier series
- Ordinary differential equations, elementary techniques an examples, linear differental equations

3 Learning Outcomes

- Beherrschung der wichtigsten Konvergenzkriterien für Reihen und ihrer Anwendung
- Sicherheit im Umgang mit elementaren Funktionen wie Exponentialfunktion, Winkelfunktionen und Logarithmus
- Verständnis topologischer Grundbegriffe und ihrer Verwendung
- Verständnis des Begriffs der Differenzierbarkeit und Beherrschung der Differentiationsregeln
- Verständnis des Riemann-Integrals und Beherrschung einfacher Integrationstechniken
- Verständnis der Differentiation von Funktionen mehrerer reeller Variablen
- Fähigkeit, Extremwertsaufgaben für Funktionen in mehreren Variablen zu lösen
- Vertrautheit mit einfachen gewöhnlichen Differentialgleichungen und Lösungsmethoden dafür

4 Requirements for Participation

Mathematik I

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, oral / written Examination, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Pflicht

9 Literature

- Finckenstein, Lehn, Schellhaas, Wegmann: Arbeitsbuch Mathematik für Ingenieure I/II, Teubner
- Meyberg/Vachenauer: Höhere Mathematik I/II, Springer-Verlag
- lecture notes of course

10 Comment

Mod	dule na	me										
	Auto	mata,	Formal	Languages and	Deci	dability						
	dule 10- 0/de	Credit	Points 5 CP	Workload 150 h	Self	- study 105 h	Duration 1 Semen	ster	Freque Every 2 semest	2.		
	guage o man	of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Martin Otto							
1	Course	es of the	e Modu	le								
	Course no. Cours		e name		Workload (CP)		Form of Teaching		Contact Hours per Week			
	04-00-0091-vu Automata, and Decide			1ages 0			Lectur Exerci	-	3			
	introduction: transition systems, words, languages; basic mathematical methods and proof patterns; finite automata and regular languages; determinism and nondeterminism closure properties and automata constructions, Kleene Theorem, Myhill-Nerode Theorem pumping lemma; grammars and the Chomsky hierrachy, context-free languages, pumping lemma, CYK algorithm; models of computation: PDA and Turing machines; decidability and recursive enumerability in the Chomsky hierarchy								terminism, e Theorem,			
3	Learning Outcomes Schöning: Theoretische Informatik kurz gefasst \newline Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale Sprachen und Komplexitätstheorie \newline Wegener: Theoretische Informatik eine algorithmenorientierte Einführung \newline Skript (elektronisch unter www.mathematik.tu-darmstadt.de#47;~otto)											
4	Requirements for Participation none											
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)											

 Module Examination (Study Examination, oral / written Examination, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Pflichtveranstaltung in Informatik-Studiengängen;

Bestandteil des Moduls "Formale Grundlagen der Imformatik" im BSc Mathematik

9 Literature

Schöning: Theoretische Informatik -- kurz gefasst

\newline

Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale Sprachen und Komplexitätstheorie

\newline

Wegener: Theoretische Informatik -- eine algorithmenorientierte Einführung

\newline

Skript (elektronisch unter www.mathematik.tu-darmstadt.de#47; otto)

10 Comment

durchgeführt als Teil einer (4+2) Veranstaltung

Mod	lule na	me								
	Prop	osition	al Logi	c and Predicate I	Logic	:				
Mod no. 04-1 012		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
1	guage o	of Instru	action		Person responsible for the Modu Prof. Dr. rer. nat. Martin Otto			odule		
1	Courses of the Module			le						
	Course no. Cours		e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0	0090-vu	Proposi Predica	tional Logic and te Logic	0		Lectur Exerci		3	
	syntax and semantics of propositional logic, functional completeness and normal forms, compactness, complete proof calculi: resolution and a sequent calculus; \newline syntax and semantics of first-order logic, structures and assignments, normal forms, Skolemization, Herbrand theorem, compactness, complete proof calculi: (ground) resolution and a sequent calculus, Gödel's Completeness Theorem; undecidability of first-order logic; \newline optional: digressions on expressiveness and model checking									
3	Learning Outcomes Die Studierenden werden mit Inhalten und Methoden der mathematischen Logik und ihrer Rolle in der Informatik vertraut gemacht. Sie lernen die grundlegenden Begriffe und Resultate der Logik, insbesondere der Logik erster Stufe, kennen und anzuwenden. Sie beherrschen die grundsätzlichen mathematischen Methoden in der Behandlung von Syntax, Semantik und formalen Beweisen, sowie die Diskussion einfacher modelltheoretischer und algorithmischer Aspekte der behandelten logischen Systeme									
4	_			rticipation prachen und Entsc	heid	barkeit				
5	Form of Examination Final Module Examination:									

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, oral / written Examination, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test (90 min), except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam (30 min). The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Pflichtveranstaltung in Informatik-Studiengängen, Bestandteil des Moduls "Formale Grundlagen der Informatik" im BSc Mathematik

9 Literature

Burris: Logic for Mathematics and Computer Science

\newline

Schöning: Logik für Informatiker

\newline

Boolos, Burgess, Jeffrey: Computability and Logic

\newline

Skript (2 Teile, elektronisch unter www.mathematik.tu-darmstadt.de#47;~otto)

10 Comment

durchgeführt als Teil einer (4+2) Veranstaltung

Mod	dule na	me								
	Line	ar Alge	bra (fo	r Teaching Degre	ees)					
Mod no. 04-1 012		Credit Points 9 CP		Workload 270 h	Self-study 180 h		Duration 2 Semester		Freque Every 2 semest	2.
Lan	Language of Instruction		uction		Person respons		ible for	the M	odule	
Geri	German				Prof	f. Dr. rer. nat	t. Jan He	endrik	Bruinie	r
1			e Modul		T					
	Course no.		Cours	se name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0067-vu Linear Algebra II (for Physical and Teaching Degrees (Mathematics)) 04-00-0117-vu Linear Algebra I (for Physical and Teaching Degrees (Mathematics))			aching Degrees		0	0		e and se	3
				S	0		Lecture and Exercise		3	
2	vector equation	ons, eige	linear m envalues	nappings, matrices s, orthogonal and u quadratic forms, d	ınita	ry transform	ations, s	symme	tric her	
3	Learning Outcomes Die Studierenden kennen Konzepte, Begriffe und Methoden der Linearen Algebra, insbesondere analytische Geometrie, Vektorräume und lineare Abbildungen, Matrizen, Eigenwerte und Orthogonalisierung. Sie sind befähigt, mathematische Lösungsstrategien im Hinblick auf die genannten Themenfelder mit den erlernten Methoden anzuwenden, mathematische Beweise nachzuvollziehen und in einfachen Fällen zu führen.									
4	Requirements for Participation none									
5			ination Examina							
	•	Modul	e Exam	ination (Technical	Exai	mination, Wi	ritten Ex	am, S	tandard	l)
	•	Module Examination (Study Examination, Special Form, Passed / Not Passed)								

Fachprüfung: In der Regel erfolgt die Prüfung durch eine Klausur, bei geringer Teilnehmerzahl gegebenenfalls mündlich. Die Form der Prüfung wird anhand der

voraussichtlichen Teilnehmerzahl in den ersten beiden Veranstaltungswochen festgelegt.

	Studienleistung: Sonderform (In der Regel erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)								
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung								
7	 Grading Final Module Examination: Module Examination (Technical Examination, Written Exam, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) 								
8	Usability of the Module Mathematics: Teaching degrees								
9	Literature K. Jänich: Lineare Algebra G.Fischer: Lineare Algebra P. Halmos: Finite-dimensional vector spaces G. Fischer: Lineare Algebra und Analytische Geometrie, Springer 2012								
10	Comment								

Mod	Iodule name										
	Seminar for subject-specififc didactics										
Module no. 04-10- 0135/de		Credit	Points 3 CP	Workload	90 h		Study Duration 60 h 1 Semester		Frequency Every 2. semester		
	guage (man	of Instru	ıction			Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger					
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week

04-00-0039-se	Seminar for subject-specific didactics: Algebra in schools	0	Seminar	2
04-00-0109-se	Seminar for subject-specific didactics: Online task training	0	Seminar	2
04-00-0112-se	Seminar for subject-specific didactics: Mathematical modeling with students	0	Seminar	2
04-00-0159-se	Seminar for subject-specific didactics: Analysis in schools	0	Seminar	2
04-00-0160-se	Seminar for subject-specific didactics: Stochastics in schools	0	Seminar	2
04-00-0249-se	Seminar for subject-specific didactics: New media in mathematical lessons	0	Seminar	2
04-00-0291-se	Seminar for subject-specific didactics: Long-term competence development	0	Seminar	2
04-10-0533-se	Didactics of Geometry	0	Seminar	2

2 Study Content

Contents are either arranged thematically according to the general principles of current educational standards or structured along the core competences ``arguing", ``modeling" and ``problem-solving".

\begin{itemize}

\item

Geometry: general experience from teaching geometry classes, spatial visualization ability, curriculum, use of technology in teaching and learning geometry, designing math lessons

\item

Algebra: construction of numbers and treatment of equations in secondary schools, arithmetic abilities, study of divisibility; misconceptions among students; high school curriculum, designing math lessons.

\item

Analysis: introductory teaching of functions, study of functions, local growth rates and the notion of limits, the notion of Riemann integrals, applications of calculus suitable for high school teaching, misconceptions among students; high school curriculum, designing math lessons

\end{itemize}

3 Learning Outcomes

siehe Teilmodule

4 Requirements for Participation

Pflichtmodul "Grundlagen des Lehrens und Lernens von Mathematik" abgeschlossen

5 Form of Examination

Final Module Examination:

• Module Examination (Technical Examination, Technical Examination, Standard)

6	Requirements on the Award of Credit Points								
7	Grading								
	Final Module Examination:								
	Module Examination (Technical Examination, Technical Examination, Weight:								
	100%, Standard)								
	10070, Standard)								
8	Usability of the Module								
	Fachdidaktisches Seminar im Wahlpflichtbereich, K-Modul								
9	Literature								
	siehe Teilmodule								
10	Comment								

Mod	Module name									
	Sem	inar in	Mathe	matics (alg), Bac	helo	r				
Mod no. 04-1		Credit Points 5 CP		Workload 150 h	Self-study 120 h		Duration 1 Semester		Frequency Every 2. semester	
Lan Geri	_	of Instru	action			son respons liendekan*ii				
1 Courses of the Module										
	Course no. Course name		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)350-se	Semina: Bachelo	r in Mathematics (al r	g), 0		Seminar		2	
2	Study	Conten	t							
	depend	ling on	topic							
3	Learni	ng Outo	comes							
		its learn								
	_			ten presentation o		intermediate	e-level m	athem	atical to	opic
				naterial on their o			1	•	c	
	- engag	ge in pro	otession	al discussions abou	it the	e content and	d presen	tation	ot a	

	mathematical talk						
4	Requirements for Participation recommended: depending on topic						
5	Form of Examination Course Examination: • [04-10-0350-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.						
6	Requirements on the Award of Credit Points Passing the Studienleistung						
7	Grading Course Examination: • [04-10-0350-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)						
8	Usability of the Module B.Sc. Mathematik						
9	Literature depending on topic						
10	Comment recommended: Mathematics: Bachelor year 3 (alg)						

Mod	dule nai	me								
	Seminar in Mathematics (alg), Bachelor									
Module no. Credit Points Workload 04-10- 5 CP 150 h					- study 120 h	Duratio 1 Semes		Frequency Every 2. semester		
	guage o	of Instru	ıction		Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Course	es of the	e Modul	le						
	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per		

					Week				
	04-10-0351-se	Seminar in Mathematics (alg), Bachelor	0	Seminar	2				
2	Study Contendepending on								
3	- learn mather	n to and written presentation of an matical material on their own ofessional discussions about th			topic				
4	_	s for Participation : depending on topic							
5	Form of Examination Course Examination: • [04-10-0351-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.								
6	Requirements Passing the St	s on the Award of Credit Poir	nts						
7	Grading Course Examination: • [04-10-0351-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)								
8	Usability of the B.Sc. Mathema								
9	Literature depending on	topic							
10	Comment recommended	: Mathematics: Bachelor year :	3 (alg)						

Module name	

	Semi	nar in	Mathe	matics (ana), Bac	helo	or						
Mod no. 04-1		Credit	Points 5 CP	Workload 150 h	Self	F-study 120 h	Duratio 1 Semes	Every 2		2.		
Lan	guage o	of Instru	ıction		Pers	son respons	ible for	the M	odule			
Geri	nan				Studiendekan*in des Fachbereichs 04							
1	Course	es of the				T		1				
	Course	Course name			Workload (CP)			n of hing	Contact Hours per Week			
	04-10-0	352-se	Semina Bachelo	r in Mathematics (ar or	na),	0		Semin	ar	2		
2	-	Content ling on t										
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk							opic				
4	_			rticipation ding on topic								
5	Course • Oral pr	_	nation:)-0352-s ion, wri	se] (Study Examination			,			-		
6	-	ements g the Stu		Award of Credit stung	Poin	its						
7	Grading Course Examination: • [04-10-0352-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)							sed / Not				
8		ity of th		ıle								

9	Literature depending on topic	
10	O Comment Mathematics: Bachelor year 3 (ana)	

Mo	dule na Sem		Mathei	matics (ana), Bad	held	or				
no. 04-	Module			Self-study		Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction English					son respons diendekan*ii					
1	Course no. Cours		le e name	Workload		(CP)	Form Teac	-	Contact Hours per Week	
	04-10-0)353-se	Semina: Bachelo	r in Mathematics (ai r	na),	0		Seminar		2
2	Study Content depending on topic									
3	Studen - give a - learn - engag	mathen	to and writ natical r ofession	ten presentation o naterial on their o al discussions abo	wn					opic
4	_			rticipation ding on topic						
5	Form of Examination Course Examination: • [04-10-0353-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active									
	1	pation ii tations.	n the dis	scussion about the	othe	er oral				

6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading Course Examination: • [04-10-0353-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 (ana)

Mod	lule na	me								
	Sem	inar in	Mathei	matics (geo), Bad	chelo	or				
Module no. 04-10- 0141/de		Credit	Points 5 CP	Workload 150 h		F-study Durati 120 h 1 Seme		Fvery 2		2.
Language of InstructionPerson responsible for the ModuleGermanStudiendekan*in des Fachbereichs 04										
1	Course	es of the	e Modul	le	u.					
	Course no.		Course	se name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)354-se	Semina: Bachelo	r in Mathematics (go r	eo),	0		Seminar		2
2	Study	Conten	t							
	depend	ling on	topic							
3	Learni	ng Outo	comes							
		its learn	-							
	•			ten presentation o		intermediate	e-level m	athem	atical to	ppic
				naterial on their o			J	+a+ia	of o	
	- engag	ge in pro	pression	al discussions abou	ut tne	e content and	a presen	tation	or a	

	mathematical talk
4	Requirements for Participation
	recommended: depending on topic
5	Form of Examination
	Course Examination:
	• [04-10-0354-se] (Study Examination, Presentation, Passed / Not Passed)
	Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)
6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading
	Course Examination:
	• [04-10-0354-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	B.Sc. Mathematik
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Bachelor year 3 (geo)

Module name										
	Seminar in Mathematics (geo), Bachelor									
Module no. Credit Poir 04-10- 0141/en		Points 5 CP	Workload 150		-study 120 h	Duration 1 Semester		Frequency Every 2. semester		
Lan Eng	0	of Instru	ıction			son respons liendekan*ii				
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week

	04-10-0355-se	Seminar in Mathematics (geo), Bachelor	0	Seminar	2			
2	Study Contendepending on							
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk							
4	_	for Participation depending on topic						
5	Form of Examination Course Examination: • [04-10-0355-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.							
6	Requirements Passing the Stu	on the Award of Credit Poin udienleistung	nts					
7	Grading Course Examin • [04-10] Passed	0-0355-se] (Study Examination	ı, Presentation, Weig	ht: 100%, Pass	sed / Not			
8	Usability of the B.Sc. Mathema							
9	Literature depending on	topic						
10	Comment recommended	: Mathematics: Bachelor year 3						

Module name

Seminar in Mathematics (log), Bachelor

no. 04-1	dule 10- 2/de	Credit	Points 5 CP	Workload 150 h	Self	- study 120 h		ration Every ser		
	guage (man	of Instru	action			s on respons liendekan*in				
1	Course	es of the	e Modu	le						
	Course no.		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)356-se	Semina Bachelo	r in Mathematics (lo or)	g),	0		Semir	ıar	2
2	Study Content depending on topic									
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk									
4	_			rticipation ding on topic						
5	Course • Studie	nleistun	nation:)-0356-s g: Oral	se] (Study Examinary presentation, writted in the seminary of the seminary)	en ez	-	-			
6	_	ements g the Stu		Award of Credit stung	Poin	ts				
7	Gradir Course	Examir)-0356-	se] (Study Examin	ation	, Presentatio	on, Weig	ght: 10	0%, Pas	ssed / Not
8		ity of the		ıle						
9	Literature depending on topic									

10	Comment recommended: Mathematics: Bachelor year 3 (log)

Mod	lule na	me								
	Sem	inar in	Mathe	matics (log), Bac	helo	r				
no. 04-1	Nodule o. Credit Points 4-10- 5 CP 142/en		Workload 150 h	3		Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction English					son respons diendekan*ii					
1	Course	es of the	e Modu	le	•					
	Course no. Course name Workload (CP) Form (Teachi		_	Contact Hours per Week						
	04-10-0)357-se	Semina: Bachelo	r in Mathematics (lo r	g),	0		Semin	ıar	2
2	2 Study Content depending on topic									
3	Studen - give a - learn - engag	mathen	to and writ natical r ofession	ten presentation o naterial on their o al discussions abou	wn					pic
4	_			rticipation ling on topic						
5	Form of Examination Course Examination: • [04-10-0357-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.									
6	Requir	ements	on the	Award of Credit	Poin	its				

	Passing the Studienleistung
7	Grading Course Examination: • [04-10-0357-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 (log)

Mod	dule na	me								
	Sem	inar in	Mathe	matics (num), Ba	chel	or				
no. 04-1	Module no. 04-10- 0143/de		Points 5 CP	Workload 150 h		-study 120 h	Duratio 1 Semes	Fvery '		2.
Ger	Language of Instruction German					son respons liendekan*ii				
1	Course no. Course nam			Workload (CI		(CP)	Form of Teaching		Contact Hours per Week	
	04-10-0)358-se	Semina: Bachelo	r in Mathematics (n	um), 0 Sen			Semin	ar	2
2	1	Conten ling on								
3	Studen - give a - learn - engag	mathen	to and writ natical r ofession	ten presentation o naterial on their o al discussions abo	wn					opic

4	Requirements for Participation
	recommended: depending on topic
5	Form of Examination
	Course Examination:
	• [04-10-0358-se] (Study Examination, Presentation, Passed / Not Passed)
	Studienleistung: Oral presentation, written expose where appropriate (Details will be
	announced at the beginning of the seminar)
6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading
	Course Examination:
	• [04-10-0358-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	B.Sc. Mathematik
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Bachelor year 3 (num)

Mod	Module name											
	Seminar in Mathematics (num), Bachelor											
Module no. 04-10- 0143/en		Credit	Points 5 CP	Workload 150 h		- study 120 h	Duration 1 Semester		Frequency Every 2. semester			
Lan Eng			e Modul	le		Person responsible for the Module Studiendekan*in des Fachbereichs 04						
	Course no. Course name			Workload	(CP)	Form Teac		Contact Hours per Week				
	04-10-0	359-se	Seminar Bachelo	r in Mathematics (n r	um),	0		Semin	ar	2		

2	Study Content depending on topic
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk
4	Requirements for Participation recommended: depending on topic
5	Form of Examination Course Examination: • [04-10-0359-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Course Examination: • [04-10-0359-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 (num)

Module name											
Seminar in Mathematics (opt), Bachelor											
Module	Credit Points	Workload	Self-study	Duration	Frequency						
no.	5 CP	150 h	120 h	1 Semester	Every 2.						

04-1 014	10- 4/de							semes	ter		
Lan	guage of Instr	uction		Person responsible for the Module							
Ger	man			Studiendekan*in des Fachbereichs 04							
1	Course no.	1	Course name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-10-0360-se Seminar in Mathematics (o Bachelor				0		Semin	ar	2		
2	Study Contendepending on										
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk										
4	Requirements recommended		_								
5	Studienleistun	nation:)-0360-s g: Oral	se] (Study Examin presentation, writt inning of the semin	ten e		-					
6	Requirements Passing the St		Award of Credit	Poir	nts						
7	Grading Course Examination: • [04-10-0360-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)										
8	Usability of the B.Sc. Mathema		ıle								
9	Literature depending on topic										

10 Comment

recommended: Mathematics: Bachelor year 3 (opt)

Mod	dule na	me								
	Sem	inar in	Mathe	matics (opt), Bac	helo	or				
no. 04-1	Module no. Credit Points 04-10- 5 CP 0144/en		Workload 150 h	Self-study		Duration 1 Semester		Frequency Every 2. semester		
Lan	Language of Instruction					son respons				
Eng	l .				Stu	diendekan*ii	ı des Fac	chbere	ichs 04	
1	Course no. Course		-		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)361-se	Semina: Bachelo	r in Mathematics (o _l r	ot),	0		Semin	ar	2
2		Conten								
3	Studen - give a - learn - engag	mathen	to and writ natical r ofession	ten presentation o naterial on their o al discussions abou	wn					opic
4	_			rticipation ling on topic						
5	Course • Studier particij	Form of Examination Course Examination: • [04-10-0361-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.								
6	_		on the	Award of Credit stung	Poin	nts				

Study Examination, Presentation, Weight: 100%, Passed / Not
cs: Bachelor year 3 (opt)

Mod	lule nan Semi		Mathei	natics (sto), Bac	helo	or				
no. 04-1			Workload 150 h	Self	Self-study D 120 h		on ster	Frequency Every 2. semester		
Lan Geri	guage o	f Instru	ıction			son respons diendekan*ii				
1	Course no. Course name					Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-03	362-se	Semina: Bachelo	r in Mathematics (st r	0), 0			Seminar 2		2
2	Study (depend									
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk									
4	Require	ements	for Pa	rticipation						

	recommended: depending on topic
5	Form of Examination Course Examination: • [04-10-0362-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Course Examination: • [04-10-0362-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 (sto)

Mod	Module name										
	Seminar in Mathematics (sto), Bachelor										
Module no. 04-10- 0145/en		Credit	Points Workload 150		150 h	Self-study 120 h Duration 1 Semester			Frequency Every 2. semester		
Language of Instruction English Person responsible for the Module Studiendekan*in des Fachbereichs 04											
1	Course no. Course name				Workload	(CP)	Form Teac		Contact Hours per Week		
	04-10-0363-se Seminar in Mathematics (s Bachelor		atics (st	o),	0		Semin	ar	2		

2	Study Content depending on topic
3	Learning Outcomes Students learn to - give an oral and written presentation of an intermediate-level mathematical topic - learn mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk
4	Requirements for Participation recommended: depending on topic
5	Form of Examination Course Examination: • [04-10-0363-se] (Study Examination, Presentation, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate, active participation in the discussion about the other oral presentations.
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Course Examination: • [04-10-0363-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature depending on topic
10	Comment recommended: Mathematics: Bachelor year 3 (sto)

Module na	Module name									
Lie A	Lie Algebras									
Module	Credit Points	Workload	Self-study	Duration	Frequency					
no.	9 CP	270 h	180 h	1 Semester	Irregular					

04-1	10-										
014	.7										
	guage of Instr				son respons						
Ger	man and Englis			Prof	Dr. rer. na	t. Nils Sc	heitha	uer			
1	Courses of th	e Modu	le		T		1				
	Course no.	Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0022-vu	Lie Alge	ebras		0		Lectui Exerci		6		
2	Study Content Semisimple Lie algebras, Cartan subalgebras, root systems, structure theory of semisimple Lie algebras, representation theory of semisimple Lie algebras, Weyl's character formula, possibly introduction to Kac-Moody algebras										
3		Learning Outcomes The students know the structure and representation theory of semisimple Lie algebras.									
4	_	Requirements for Participation recommended: Algebra									
5	Form of Exam Final Module	Examina	ation:								
			ination (Technica) in, Standard)	al Exar	nination, or	al / writ	ten Ex	aminati	on,		
	only a small n form of an ora	umber on al exam. d during	the exam is taker of potential partice. The decision abouthe first two week exam.	ipants out the	. In this case form of the	e, the exa exam is	am car taken	n be tak and	en in the		
6	Requirement Passing the Fa		Award of Credi	t Poin	ts						
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)										
8	Usability of the B.Sc Mathema		u le c. Mathematik, M	Л.Sc. M	lathematics						
9	Literature Serre: Comple	ex semis	mple Lie algebra	s, Spri	nger						

Humphreys: Introduction to Lie algebras and representation theory, Springer
Bourbaki: Lie groups and Lie algebras, Springer
Carter: Lie algebras of finite and affine type, Cambridge University Press
Kac: Infinite dimensional Lie algebras, Cambridge University Press

Comment
recommended: Mathematics: Master (alg)

Module Description

Mod	dule na	me									
	Alge	braic N	lumber	Theory							
Moo no. 04-1				_	F requency Frregular						
	~ ~	of Instru d Englis				son respons		the Module cheithauer			
1	Course	es of the	e Modu	le							
			Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week	
	04-00-0)181-vu	Algebra	ic Number Theory		0	Lectu Exerc		re and se	6	
2	Study Content Algebraic integers, Dedekind rings, ideals, prime ideal decomposition, ideal class group, unit group, extensions of Dedekind rings, ramification, orders, possibly further topics as the theory of valuations, L-series or introduction to class field theory										
3	The stu		ındersta	nd the basic notion typical questions.		id technique	s of alge	braic 1	number	theory	
4	_		for Par : Algebr	rticipation a							
5	_	Module I Modul		ition: ination (Technical	Exar	nination, or	al / writ	ten Ex	aminati	on,	
	Fachpr			in, Standard) the exam is taken	in fo	rm of a writt	ten test,	except	t when	there are	

only a small number of potential participants. In this case, the exam can be taken in the

	form of an oral exam. The decision about the form of the exam is taken and
	communicated during the first two weeks of the lecture, based on the prospective number
	of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature
	Neukirch: Algebraic number theory, Springer
	Lang: Algebraic number theory, Addison-Wesley
	Milne: Algebraic number theory, course notes
	Zagier: Zetafunktionen und quadratische Zahlkörper, Springer
	Cassels, Fröhlich: Algebraic number theory, Thompson
10	Comment
	recommended: Mathematics: Master (alg)

Mod	Module name										
	Spectral Theory										
Module no. 04-10- 0150/de		Credit	Points 5 CP	Workload	Vorkload 150 h		-study Duration 105 h 1 Seme			Frequency Every 2. semester	
	Language of Instruction German					Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber					
1	Course	es of the	e Modul	e							
	Course no.		Course	e name			Workload (CP) Form of Teaching		-	Contact Hours per Week	
	04-00-0182-vu Spectral Theory			0		Lectur Exerci		3			
2	Study Content Banach and C*-algebras, spectral theory in Banach and C*-algebras, the Gelfand										

theorems and functional calculus, positivity in C*-algebras, approximating units and quotients of C*-algebras, states and representations of C*-algebras. 3 **Learning Outcomes** Participants of this course are enabled to define C*-algebras, to construct commutative C*-algebras and their representations, to develop the spectral theory of commutative C*algebras and to use these results to classify commutative C*-algebras. They understand the meaning of the homomorphy theorem and the importance of positivity for general C*-algebras. Finally, they are able to demonstrate the existence of (in a sense) sufficiently many states and to employ this fact to prove the celebrated representation theorem by Gelfand, Naimark and Segal. **Requirements for Participation Functional Analysis** Form of Examination 5 Final Module Examination: Module Examination (Technical Examination, Technical Examination, Standard) Module Examination (Study Examination, Study Examination, Passed / Not Passed) **Requirements on the Award of Credit Points** 6 7 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) 8 **Usability of the Module** B.Sc.Math, B.Sc.Math(bilingual), B.Sc.WiMa, B.Sc.ME, B.Sc.MCS: Compulsory elective course, M.Sc.Math: specialisation and supplementary area. Literature D. Werner: Funktionalanalysis, J.B. Conway: A Course in Functional Analysis. Comment 10

Mod	lule na	me									
	Com	plexity	Theory	/							
no. 04-1 019	1/en		6 CP	Workload 180 h			Duratio 1 Seme	Every		2.	
	Language of Instruction English					son respons rer. nat. Kor			odule		
1	Course	s of the	e Modu	le							
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week	
	04-00-0	267-vu	Comple	xity Theory		0		Lectur Exerci		4	
	Models of computation and polynomially bounded resources; decision problems SAT, 3SAT, Independent Set, Clique, and relations among them; complexity class NP and Cook-Levin Theorem; further NP-complete problems; approximation algorithms and non-approximability; PSPACE-completeness; Savitch's Theorem; Immerman-Szelepcs ´enyi Theorem; L, NL and graph reachability; parallel complexity and circuits, P-completeness; cryptographic one-way functions and UP; randomized complexity; polynomial hierarchy										
3	Learning Outcomes Nachdem Studierende diese Veranstaltung besucht haben, koennen sie die grundlegenden Anliegen und Methoden der klassischen Komplexitätstheorie wiedergeben. Sie erkennen die Bedeutung und die Unterschiede des asymptotischen Ressourcenbedarfs "Zeit" und "Speicher" von einem Algorithmus und von einem Problem. Sie können die wesentlichen Komplexitätsklassen erklären und bewerten; sowie vergleichen, d.h. Beziehungen zwischen ihnen beweisen, und Beispielprobleme in sie einordnen.										
4	ein Pro	semina	r aus de	rticipation r Logik und Logik nrung in die mathe		_	oder Foi	rmale (Grundla	ngen der	
5		Iodule I			ımina	ation, Study	Examina	ation,	Passed	/ Not	

	Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading
,	Final Module Examination:
	 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
	Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc.Math: Wahlpflichtbereich M.Sc.Math: Ergänzungsbereich
9	Literature
	Uwe Schöning: Theoretische Informatik kurzgefasst;
	Garey#47;Johnson: Computers and Intractability Papadimitriou: Computational Complexity
10	Comment

Mod	dule na	me									
	Cate	gorical	Logic								
Module no. 04-10- 0193/en		Credit	redit Points 5 CP Workload 150 h		Self	-study 105 h	Duration 1 Semester		Frequency Irregular		
Language of Instruction English					Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher						
1	Courses of the Module										
	Course	e no.	Cours	e name			Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0)193-vu	Categor	ical Logic			0		Lectur Exerci		3
2	•	Conten an close		ories, elementa	ary t	opos	, internal log	gic, (pre)sheav	es	

3	Learning Outcomes
	Students know how to interpret various logic calculi in appropriate categories like
	presheaves etc. This way they develop an understanding of intuitionistic logic.
4	Requirements for Participation
	recommended: Introduction to Mathematical Logic
5	Form of Examination
	Final Module Examination:
	 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are
	only a small number of potential participants. In this case, the exam can be taken in the
	form of an oral exam. The decision about the form of the exam is taken and
	communicated during the first two weeks of the lecture, based on the prospective number
	of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature
	Lecture notes provided online
10	Comment
	recommended: Mathematics: Master (log)

Module name									
Category Theory									
Module no.	Credit Points	Workload	Self-study	Duration	Frequency				
04-10- 0194/en	5 CP	150 h	105 h	1 Semester	Irregular				
Language o	of Instruction		Person responsible for the Module						

Engl	lish		Prof. Dr. rer. nat. Thomas Streicher							
1	Courses of the	e Module								
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0194-vu	Category Theory	0	Lecture and Exercise	3					
2	Study Content categories, functors, Yoneda lemma, limits and colimits, adjoints monads									
3	Learning Outcomes Students can formulate basic notions of algebra and topology in categorical terms. They know how to use the Yoneda lemma, the notions of limits and colimits and master the notion of adjunction in its various manifestations.									
4	Requirements for Participation recommended: Introduction to Mathematical Logic									
5	 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 									
6	Requirements Passing the Fac	on the Award of Credit chprüfung	Points							
7		Examination: e Examination (Technical) : 100%, Standard)	Examination, oral / wr	itten Examinat	ion,					
8	Usability of the B.Sc Mathema	ie Module tik, M.Sc. Mathematik, M.	Sc. Mathematics							
9	Literature Lecture notes p	provided online								
10	Comment recommended:	: Mathematics: Master (lo	g)							

Moduno. 04-10 0199 Lang Germ 1 2 3 1	ule 0- /de ruage c	Credit of Instru	9 CP	istics Workload 270 h		- study 180 h	Duratio 1 Seme		Freque	ency
no. 04-10 0199 Lang Germ 1 0 2 3 1	ule 0- 7/de guage o nan Course	Credit of Instru	Points 9 CP uction	Workload		•			Freque	ency
Lang Germ 1 (uage on nan Course	es of the			Pers			ster	Irregul	-
1 (c) (d) (d) (d) (d) (d) (d) (d) (d) (d) (d	Course		e Modul			Person responsi		sible for the Module		
2 5 1 1				le	1101	7 2 1 7 1 2 1 1 1 1 1	., 1,110110			
2 S I			Course	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
3 1	04-00-0	073-vu	Mathem	atical Statistics		0		Lectur Exerci		6
-	Study Content Estimation of distributions, VC theory, density estimation, point estimation, statistical tests, confidence intervals, nonparametric regression. Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of mathematical statistics - are able to extend their knowledge in this field									
	_			ticipation ility Theory						
	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Requirements on the Award of Credit Points									

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature Witting: Mathematische Statistik I
10	Comment recommended: Mathematics: Master (sto)

Mod	Module name										
	Non-	Life In	surance	Mathematics							
	Module no. Credit Points Workload		Workload	Self	-study	Duratio	m	Freque	encv		
04-1	.0- 0/de	Great	5 CP	150 h					Irregul	•	
Lan ; Geri		of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Michael Kohler						
1	Course	es of the	e Modu	le							
	Course no. Course n		e name	Workload ((CP)	Form of Teaching		Contact Hours per Week		
	04-00-0)197-vu	Non-Lif Mathen	e Insurance natics		0		Lecture and Exercise		3	
2	Study Content Statistical methods for calculation of the premium of a non-life insurance. Possible societal implications will be addressed in the lecture.										
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an intermediate level of understanding of the methods employed in non-life insurance mathematics										
	- are al	are able to extend their knowledge in this field									

	Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly.						
4	Requirements for Participation recommended: Probability Theory, Mathematical Statistics						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)						
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.						
6	Requirements on the Award of Credit Points Passing the Fachprüfung						
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)						
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics						
9	Literature Mack: Schadenversicherungsmathematik						
10	Comment recommended: Mathematics: Master (sto)						

Module na	Module name										
Nonsmooth Optimization											
Module no.	Credit Points	Workload	Self-study	Duration	Frequency						
04-10- 0202	5 CP	150 h	105 h	1 Semester	Irregular						
Language German and	of Instruction d English		Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich								

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-00-0199-vu	Nonsmooth Optimization	0	Lecture and Exercise	3			
2	method, cuttin Nonsmooth eq	t etimization: Examples, subding g plane method, epsilon-subutions: Examples, generalizes, semismooth Newton met	odifferential, bundle n zed Newton methods,	nethods, applic	ations;			
3	knows the spknow applicaare proficient	comes ic theory and methods for necific difficulties and the restions and can solve these. in methods for the solution applications for non-smooth	ulting concepts for no	on-smooth prob	lems.			
4	Requirements for Participation recommended: Introduction to Optimization							
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.							
6	Requirements Passing the Fa	s on the Award of Credit Po chprüfung	ints					
7		Examination: e Examination (Technical Ex :: 100%, Standard)	xamination, oral / wr	itten Examinati	ion,			
3	Usability of the M.Sc. Mathem	ne Module atik, M.Sc. Mathematics						

9 Literature

C. Geiger, C. Kanzow: Theorie und Numerik restringierter Optimierungsaufgaben W. Alt: Numerische Verfahren der konvexen, nichtglatten Optimierung J.F. Bonnans, J. Gilbert, C. Lemaréchal, C.A. Sagastizábel: Numerical Optimization

10 Comment

recommended: Mathematics: Master (opt)

offered alternatingly with Game Theory and Interior Point Methods for Convex Optimization; recommended for Studienrichtung Mathematik in B.Sc. Mathematik

Mod	lule naı	me									
	Inter	ior Poi	nt Metl	hods for Convex	Opt	imization					
Module no. Ca 04-10- 0203		Credit	Points 5 CP	Workload 150 h	Self-study 105 h Duration 1 Semest				•		
	Language of Instruction German and English					Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich					
1 Courses of the Module											
	Course no. Cour		Course	e name		Workload	(CP)	Form Teac		Contact Hours per Week	
	04-00-0	200-vu		Point Methods for Optimization		0		Lecture and Exercise		3	
2	Study Content Introduction: Examples, classical barrier method, central path, Newton's method; interior point methods for linear optimization: primal path following method, primal-dual path following method, convergence theory, complexity; interior point methods for general convex optimization: selfconcordant barrier funtions, selfconcordance and Newton's method, short step method, long step method, applications										
3	Learning Outcomes Students - know and understand the theory and concepts of modern interior-point methods - are familiar with the general methodology to construct interior-point methods for convex optimization problems based on selfconcordant barrier functions - know application scenarios of the general theory										
4	_	Requirements for Participation recommended: Introduction to Optimization									

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

- S.J. Wright: Primal-Dual Interior Point Methods;
- Y. Nesterov, A. Nemirovski: Interior-Point Polynomial Algorithms in Convex Programming;
- J. Renegar: A Mathematical View of Interior-Point Methods in Convex Optimization;
- Y. Ye: Interior Point Algorithms: Theory and Analysis; Wiley- Interscience

10 Comment

recommended: Mathematics: Master (opt)

offered alternatingly with Game Theory and Nonsmooth Optimization; recommended for Studienrichtung Mathematik in B.Sc. Mathematik

Module Description

Module name **Category Theory** Module Frequency Credit Points | Workload Self-study Duration no. Every 2. 04-10-5 CP 150 h 105 h 1 Semester semester 0210/de **Language of Instruction** Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher. German

1	Courses of the	e Module							
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-00-0210-vu	Category Theory	0	Lecture and Exercise	3				
2	Study Contencategories, fur		imits and colimits, adjoint	s monads					
3	-		s and techniques together a, topology etc.						
4	Requirements for Participation Einf. in die Logik								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard) • Module Examination (Study Examination, Study Examination, Passed / Not Passed)								
6	Requirements	s on the Award of Cred	lit Points						
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) • Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)								
8	Usability of the Module								
9	Literature Skript online 6	erhältlich							
10	Comment								

Mod	dule na	me								
	Cate	gorical	Logic							
Module no. 04-10- 0211/de		Credit	Points 5 CP	Workload 150 h			Duration 1 Semester		Frequency Every 2. semester	
	guage o	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher					
1	Course	es of the	e Modu	le	I					
	Course	e no.	Course	e name		Workload	(CP)	Forn Teac	_	Contact Hours per Week
	04-00-0211-vu Categor			ical Logic		0		Lectur Exerci		3
2	Study Content cartesian closed categories, elementary topos, internal logic, (pre)sheaves									
4	Learning Outcomes There should be developed an understanding of how to interpret calculi of mathematical logic in categories different from Set. In particular, students should develop an understanding of the semantics of intuitionistic logic. Requirements for Participation									
5	Form o	of Exam Todule I	ination							
	•	Modul	e Exami	ination (Technical		·			-	
	•	Passed)		ination (Study Exa	ımına	ition, Study	Examina	ation,	Passed	/ Not
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradi r Final M	ig Iodule I	Examina	ition:						
	•		e Exami Standar	ination (Technical [·] d)	Exan	nination, Te	chnical l	Examiı	nation,	Weight:

	Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
9	Literature Skript online erhältlich
10	Comment

Mod	Module name									
	Mod	el Theo	ory							
Module no. Credi 04-10- 0212/en		Credit	Points 5 CP	Workload 150 h		- study 105 h	Duration 1 Semester		Frequency Irregular	
	5 5					on respons Dr. rer. na			odule	
1				le e name	ame		Workload (CP)		n of hing	Contact Hours per Week
	04-00-0)212-vu	Model 7	Theory		0		Lecture and 3 Exercise		3
2	model theores	ms (exp	ctions (e ressive e types a	e.g. ultra-products completeness resu nd saturation prop	ĺts); r	nodel theor	etic gam	es, bac	kforth,	partial
3	Learning Outcomes Students understand and are able to apply the notions, methods and results of classical model theory treated in the course. They have developed an advanced level of understanding of the model theory of first-order logic, which enables them to extend their knowledge in this field and to relate it to potential application areas under supervision.									
4	Requir	ements	for Pa	rticipation						

recommended: Introduction to Mathematical Logic

Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 **Requirements on the Award of Credit Points**

Passing the Fachprüfung

Grading

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

Literature

Cori/Lascar: Mathematical Logik Chang/Keisler: Model Theory

Hodges: Model Theory

Hodges: A Shorter Model Theory Marker: Model Theory, an Introduction

Rothmaler: Modelltheorie

Poizat: A Course in Model Theory

10 Comment

recommended: Mathematics: Master (log)

Due to content overlap, this course cannot be combined with Classical and Non-Classical

Model Theory.

Module Description

Module name

DDF II D Navior Stales Favotions

PDE II.B Navier-Stokes-Equations											
		Credit Points	Workload	Self-study	Duration	Frequency					
	no.	5 CP	150 h	105 h	1 Semester	Irregular					
	04-10-										

021	3										
	iguage of Insti	ruction	Pers	son responsible f	or the Module						
	man and Engli			f. Dr. rer. nat. Mat							
1	Courses of th	ie Module									
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0213-vu	PDE II.B Navier-Stok Equations	ces-	0	Lecture and Exercise	3					
2	divergence pr	Development and analytical treatment of the fundamental equations of fluid dynamics, divergence problems, methods for the solution using evolution equations and the Stokes semi-group, Kato-Iteration, weak solutions.									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of the Navier-Stokes equations - are able to extend their knowledge in this field - are able perform supervised research in this field										
4	_	s for Participation l: Functional Analys	is, Partial D	ifferential Equatio	ons I						
5				mination, oral / w	ritten Examinati	ion,					
	only a small r form of an ora communicate	Usually the exam is number of potential pal exam. The decision did during the first two king the exam.	participants n about the	. In this case, the case form of the exam	exam can be tak is taken and	en in the					
6	Requirement Passing the Fa	s on the Award of (achprüfung	Credit Poin	its							
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)										
8	Usability of t	he Module									

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Galdi: An introduction to the mathematical theory of the Navier-Stokes equations. Springer Verlag

Sohr: The Navier-Stokes equations. An elementary functional analytic approach.

Birkhäuser Verlag

Temam: Navier-Stokes equations. Theory and numerical analysis. North-Holland

Publishing Co.

10 Comment

recommended: Mathematics: Master (ana) Builds on "Partial Differential Equations I".

Upon approval, contents of two PDE II.X-courses may replace "Partial Differential Equations II" and can be combined with the content from "Partial Differential Equations I" as an "Advanced Course in Analysis".

Combinations of two or more PDE II.X-courses as additional courses require approval, too.

Mod	Module name										
	Harn	nonic A	nalysis	i							
no. 04-2	dule 10- 6/de	Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester		
Lan	guage (of Instru	ıction		Pers	on respons	ible for	the M	odule		
Ger	man				Prof	Dr. rer. nat	t. Matthi	as Hie	ber		
1	Course	Courses of the Module									
	Course no. Cours			e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)216-vu	Harmonic Anylsis			0			re and se	3	
2	Study Content Theory of distributions, interpolation of function spaces, singular integrals.										
3	Studen the cou	Learning Outcomes Students understand and are able to apply the notions, methods and results treated in the course. They develop an advanced level of understanding of interpolation theory for functions on Euclidean spaces in the context of singular integrals and are able to extend									

	their knowledge in this field.
4	Requirements for Participation Measure and Integration.
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module Specialisation area Master Mathematics.
9	Literature Grafakos: Classical Fourier Analysis
10	Comment

Mod	Module name										
Algebraic Geometry											
Module no. 04-10- 0222		Credit	Points 9 CP	Workload	270 h		study 180 h	Duration 180 h 1 Semester		Frequency Irregular	
Language of Instruction German and English Courses of the Module					Person responsible for the Module Prof. Dr. rer. nat. Torsten Burkhard Wedhorn						
	Course no. Course name			Workload		(CP) Form			Contact Hours per Week		
	04-00-0221-vu Algebraic Geometry					Lectur Exerci	-	6			

2	Study Content Varieties and schemes, morphisms, dimension, singularities
3	Learning Outcomes Students understand basic notions and methods of algebraic geometry and are able to study and solve geometric and algebraic problems using the presented methods.
4	Requirements for Participation recommended: Algebra
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature K. Hulek, Elementary algebraic geometry, AMS R. Hartshorne: Algebraic geometry, Springer I. R. Shafarevich: Basic algebraic geometry 1,2 U. Görtz, T. Wedhorn: Algebraic Geometry, Vieweg
10	Comment recommended: Mathematics: Master (alg)

Module name

	Auto	morph	ic Forn	าร								
no. 04-1	dule 10- 4/de	Credit	Points 5 CP	Workload 150 h				Duration 1 Semester		ency 2. ter		
Lan	guage o	of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Nils Scheithauer							
1	Course	es of the	e Modu	le								
	Course	e no.	Cours	e name	name		Workload (CP)		n of hing	Contact Hours per Week		
	04-00-0)223-vu	Automo	orphic Forms		0		Lectur Exerci		3		
2	Study Content Dirichlet L-functions, modular forms, Eisenstein series, theta series, Hecke operators and L-functions, automorphic forms for GL(1) and GL(2).											
3	Learning Outcomes Die Studenten verstehen fortgeschrittene Techniken der Zahlentheorie wie automorphe Formen und L-Funktionen und können diese anwenden.											
4	Requirements for Participation Einführung in die Algebra, Complex Analysis											
5		of Exam Iodule I Modul	Examina		Exan	nination, Te	chnical I	Examiı	nation,	Standard)		
6	Requir	ements	on the	Award of Credit	Poin	ts						
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)											
8	Für B.S	-	, B.Sc.M	ule Iath (bilingual), B. ir M.Sc.Math, M.S		-	-					
9	Literature D. Bump: Automorphic Forms and Representations, Cambridge University Press A. Knapp: Elliptic Curves, Princeton University Press S. Lang: Algebraic Number Theory, Addison-Wesley D. Bump et.al.: An Introduction to the Langlands Programm, Birkhäuser											

	J.H. Bruinier, G. van der Geer, G. Harder, D. Zagier: The 1-2-3 of Modular Forms, Springer
10	Comment

Mod	dule na	me								
	Basi	c Applie	ed Proc	of Theory						
no. 04-1	Module no. Credit Points 04-10- 5 CP 0225/en				- study 105 h	Duration 1 Semester		Frequency Irregular		
	Language of Instruction English					son respons . Dr. phil. na				
1	Course	es of the	e Modu	le	,					
			e name		Workload	(CP)	Form Teac		Contact Hours per Week	
	04-00-0224-vu Basic Applied Proof Theo					0		Lectur Exerci		3
	This course gives a brief introduction to some of the major techniques of applied proof theory, namely so-called proof interpretations. The main methods studied are: no-counterexample interpretation (Kreisel), modified realizability, functional ('Dialectica') interpretation (Gödel) and their monotone variants.									
3	Learning Outcomes Students 1) understand and are able to use formal calculi of intuitionistic logic, arithmetic and analysis (also in higher types); 2) understand the soundness and characterization theorems for the proof interpretations treated (modified realizability, functional interpretation, monotone Functional interpretation); 3) can refer to basic applications of these interpretations (e.g. the elimination of the binary König's lemma); 4) can apply the methods to simple proofs in mathematics.									
4	recomi	mended	Introd	rticipation uction to Mathema taught in CS prog		•				

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Kohlenbach, Ulrich: 'Applied Proof Theory: Proof Interpretations and Their Use in Mathematics'. Springer Monograph in Mathematics, xx+536pp., 2008, Chapters 1-10.

10 Comment

recommended: Mathematics: Master (log)

Due to content overlap, this course cannot be combined with Applied Proof Theory.

Mod	Module name											
	Complex Analysis											
Module no. 04-10- 0226/en		Credit	Points 5 CP	Workload 150		elf-s	study 105 h	Duration 1 Semester		Frequency Every 2. semester		
Lan Eng		of Instru	ıction			Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Course	es of the	e Modul	le	•							
	Course no. Course name						Form of Teaching		Contact Hours per			

					_						
					Week						
	04-00-0225-vu	Complex Analysis	0	Lecture and Exercise	3						
2	Study Conten	t									
	Formula; anal	Cauchy-Riemann differential equations, curve integrals, Cauchy's Integral Theorem and Formula; analyticity, Liouville's Theorem and Fundamental Theorem of Algebra; Winding Number; Laurent series and isolated singularities, Residue Theorem.									

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop a basic level of understanding of Complex Analysis
- are able to recognise the treated concepts in various fields of mathematics.

4 Requirements for Participation

recommended: Analysis and Linear Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination,
 Weight: 100%, Standard)

	Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	B.Sc. Mathematik, LaG Mathematik
9	Literature Freitag: Funktionentheorie I, Springer Remmert: Funktionentheorie I Conway: Functions of one complex variable, Springer
10	Comment recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mod	Module name										
	Rese	arch Pr	oject P	reparation							
Mod no. 04-1 022	LO-	Credit Points 5 CP		Workload 150 h			Duration 1 Semester		Frequency Every 2. semester		
	guage c					son respons					
Geri	nan and	l Englis	h		Prof	Dr. rer. na	t. Stefan	Ulbric	:h		
1	1 Courses of the Module										
			Form Teac		Contact Hours per Week						
	04-00-0	228-vu	Researc	h Project Preparatio	n	0		Lectur Exerci		3	
2	Introdu		scienti	fic research (maste tle, planning the p		-	ure rech	erche,	state of	science,	
3	Learning Outcomes Students - know the usual requirements for a scientific text - can make a literature review on a clearly defined scientific problem - are able to plan the work schedule for an own thesis or report										
4	_			rticipation e advanced course	es plu	s seminar					

5	Form of Examination
	Final Module Examination:
	Module Examination (Study Examination, Special Form, Passed / Not Passed)
	Studienleistung: Short oral or written presentation of the topic of the thesis and its scientific placement. Credits are awarded at the time of registering the thesis.
6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment
	recommended: Mathematics: Master

Mod	lule na	me									
	Finit	e Mode	el Theo	ry					•		
Module no. 04-10- 0231/en		Credit Points 5 CP		Workload 150		lf-study 105 h	Duration 1 Semester		Frequency Irregular		
	Language of Instruction English					Person responsible for the Module Prof. Dr. rer. nat. Martin Otto					
1	Course	s of the	e Modul	le	•						
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week	
	04-00-0	230-vu	Finite M	Iodel Theory		0		Lectur Exerci	-	3	
2	finite v		assical r	nodel theory, fai ne Ehrenfeucht-F			-		-		

Gaifman); zero-one laws (Fagin); core results of descriptive complexity (Fagin, Immerman-Vardi, Abiteboul-Vianu)

3 **Learning Outcomes**

Students understand and are able to apply the notions, methods and results of finite model theory treated in the course. They have developed an advanced level of understanding of logical systems in terms of their expressiveness and algorithmic properties over finite structures, which enables them to extend their knowledge in this field and allows them to conduct related research under supervision.

Requirements for Participation

recommended: Introduction to Mathematical Logic. Alternatively: Logic as taught in CS programmes

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 **Requirements on the Award of Credit Points**

Passing the Fachprüfung

Grading

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

Literature

Ebbinghaus, Flum: Finite Model Theory

Grädel et al.: Finite Model Theory and Its Applications

Libkin: Elements of Finite Model Theory

lecture notes (available on http://www.mathematik.tu-darmstadt.de/~otto)

10 Comment

recommended: Mathematics: Master (log)

Due to content overlap, this course cannot be combined with Classical and Non-Classical

Model Theory.

Mod	lule na	me								
	Fluid	-Struct	ure Int	eraction						
Mod no. 04-1 0232		Credit	Credit Points Workload 5 CP		Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
Lan Engl	guage o	of Instru	ıction			son respons . Dr. rer. nat				
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name	Workload (C		(CP)	Form of Teaching		Contact Hours per Week
	04-00-0)231-vu	Fluid-St	ructure Interaction		0		Lectur Exerci		3
3	In this lecture we will focus on solving the systems of partial differential equations describing the interaction of a fluid and a solid. This special type of problem is usually described by two coupled systems, one describing the motion of the fluid and one the motion and, in the case of a deformable body, the deformation of the solid. Learning Outcomes After attending this lecture, students will be able to apply methods of mathematical fluid mechanics in the context of the fluid-structure interaction and transfer previous results to									
4	Requir		for Pa	rticipation						
	Partial	differer	itial equ	ations						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard) • Module Examination (Study Examination, Study Examination, Passed / Not Passed)									
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradin Final M	ı g Iodule I	Examina	ntion:						

Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
 Usability of the Module Vertiefungsmodul Partielle Differentialgleichungen.
 Literature Lecture notes
 Comment

Mod	lule na	me								
Mathematical Foundations of Computer Science										
Module no. 04-10- 0233/de		Credit Points 9 CP		Workload 270 h	Self-study 180 h		Duration 2 Semester		Frequency Every 2. semester	
Lan ; Geri		of Instru	action			on respons Dr. rer. na			odule	
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)090-vu	Proposi Predica	tional Logic and te Logic		-		Lecture and Exercise		3
	04-00-0	0091-vu		ta, Formal Languago cidability	es	-		Lecture and Exercise		3
2	Study Content finite automata and regular languages, Kleene Theorem, Myhill–Nerode Theorem, grammars and Chomsky hierarchy, context-free languages, pumping lemmas, models of computation, PDA, Turing machines, decidability and recursive enumerability; propositional logic: compactness, complete proof calculi; first-order logic: structures and assignments, Skolemisation, Herbrand Theorem, compactness theorem, complete proof calculi (Gödel's completeness result), undecidability of first-order logic; optional: digressions on expressiveness and model checking									
3	Learni	ng Outo	comes							
	Studen	ts unde	rstand a	and are able to app	oly th	e notions, m	ethods a	and res	sults tre	ated in the

course. They have developed a basic level of understanding of formal language theory, basic computability theory and of methods of mathematical logic in application to fundamental issues in theoretical computer science. They are able to recognise the relevant concepts and ideas in related fields of mathematics and theoretical computer science.

4 Requirements for Participation

recommended: solid mathematical foundations in Analysis and Linear Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik

9 Literature

Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, formale Sprachen und Komplexitätstheorie

Schöning: Theoretische Informatik – kurz gefasst Boolos, Burgess, Jeffrey: Computability and Logic

Burris: Logic for Mathematics and Computer Science

	Skripte (elektronisch unter <u>www.mathematik.tu-darmstadt.de/~otto</u>)
10	Comment
	recommended: Mathematics: Bachelor year 2

Mod	dule na	me								
	Inte	polatio	n Theo	ory						
no.	04-10- 5 C		Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular	
Lan	guage (of Instru	ıction		Per	son respons	ible for	the M	odule	
Gen	man and	d Englis	h		Prof	f. Dr. rer. na	t. Reinha	ard Far	wig	
1	Course	es of the	e Modul	le		1		1		<u> </u>
	Course no. Co		Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)233-vu	Interpol	ation Theory		0		Lecture and Exercise		3
3	Learni Studen - under - devel - are al	ng Outous ts estand a cop an acoole to expless performance of the performance of the color of the performance of the performanc	comes and are advanced attend the orm sup	able to apply the n level of understar eir knowledge in t ervised research ir	otior nding	ns, methods a g of the theo ield	and resu	lts trea	ated in	
4	_			rticipation onal Analysis						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are									

	form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Bergh, J., Löfström, J., Interpolation Spaces. An Introduction. Springer-Verlag 1976. Hans Triebel. Interpolation Theory, Function Spaces, Differential Operators. Elsevier Science Publishing 1978 Lunardi, A., Interpolation Theory. Publ. Scuola Normale Superiore, Vol. 9, 2009
10	Comment recommended: Mathematics: Master (ana)

	Com	olex Ar	nalysis	2						
Module no. 04-10- 0235/de		Credit Points 5 CP		Workload 150 h		If-study Duration 105 h 1 Semes		Every 2		2.
	Language of Instruction German			Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Courses of the Module									
	Course no. Course			e name		Workload	(CP)	Form Teac	- 0-	Contact Hours per Week
	04-00-0234-vu Complex Analysis 2					Lectur Exerci		3		

	Partial fraction decomposition and product expansions, Gamma function
	Elliptic functions and elliptic curves
3	Learning Outcomes After successfully passing this module, students can apply methods of complex analysis to geometric and algebraic problems.
4	Requirements for Participation Complex Analysis
5	Form of Examination Final Module Examination:
	Module Examination (Study Examination, Study Examination, Passed / Not Passed)
	Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination:
	 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
	• Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module
9	Literature Freitag, Busam: Funktionentheorie 1 Conway: Functions of one complex variable I+II
10	Comment

Module name											
Inco	Incompleteness of Formal Systems										
Module	Credit Points	Workload	Self-study	Duration	Frequency						

no. 04-1 023	10- 8/en		5 CP	150 h		105 h	1 Seme	ster	Irregul	lar		
Lan Eng		of Instru	uction		Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher							
1	Course	es of the	e Modul	le	•							
	Course	e no.	Course	e name		Workload	(CP)	Forn Teac	n of hing	Contact Hours per Week		
	04-00-0)236-vu	Incomp Systems	eteness of Formal		0		Lectui Exerci	re and ise	3		
2	-	Conten Incom		s Theorems, Löb's	Theo	orem, Proval	bility Log	gic				
3	Studen Goedel	l's first a	rstand to	he difference betw d Incompletness T hat formal system	heor	ems as well	as Loeb's	s Theo	-			
4	_			ticipation action to Mathema	atical	Logic						
5		Iodule I Modul			Exar	nination, or	al / writi	ten Ex	aminati	on,		
	only a form of commit	small nu f an ora inicated	umber o l exam.	the exam is taken f potential participe. The decision abouthe first two week exam.	oants t the	. In this case form of the	e, the exa exam is	am car taken	n be tak and	en in the		
6	-		on the	Award of Credit	Poin	ts						
7	Gradin Final M	Iodule I Modul		tion: nation (Technical Standard)	Exar	nination, or	al / writi	ten Ex	aminati	on,		
8		-	ne Modu tik, M.S	ile c. Mathematik, M.	Sc. N	Iathematics						

9	Literature lecture notes provided online
10	Comment recommended: Mathematics: Master (log)

Mod	dule na	me										
	Intro	ductio	n to Ga	me Theory								
no. 04-1	lule 10- 1/en	Credit	Points 5 CP	Workload 150 h		- study 105 h	Duratio 1 Seme	_	Freque Every semes	2.		
Lan Eng		of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich							
1	Course no. Course name					Workload	(CP)	Form Teac		Contact Hours per Week		
	04-00-0)239-vu	Introdu	ction to Game Theor	ry	0	Lecture Exercise			3		
2	Study Content Non-cooperative and cooperative game theory (e.g. coalitions). Sequential and strategic games. Fixed point theorems (e.g. Brouwer). Various concepts of solution of a game (e.g. Nash equilibrium). Theorems of existence of solution (e.g. minimax theorem). Impossibility theorems (e.g. Arrow paradox for voting systems).											
3	Learning Outcomes Students become aware of different areas in game theory, of its practical purposes, and of its current limits. They will be able to discuss technical notions in terms of examples, derive classical results in non-cooperative game theory, and exemplify the limitations of these results. They will also be able to evaluate game-theoretic results as modelling tools.											
4	_			rticipation tisches Grundwiss	en aı	ıs den 1,2,3	Fachsen	nestern	1			
5		Form of Examination Final Module Examination:										

Module Examination (Study Examination, Study Examination, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Standard) 6 **Requirements on the Award of Credit Points** 7 Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) **Usability of the Module** Ba.Sc.Math: Wahlpflichtbereich, Ergänzungsbereich Literature Osborne, Martin J. (2004), An introduction to game theory 10 Comment

Mod	lule naı	me									
	Curv	e Estim	nation								
no. 04-1	lule 10- 3/de	Credit	Points 9 CP	Workload 2	70 h		•	Duratio 1 Seme		Freque Irregul	•
	Language of Instruction German 1 Courses of the Module						on respons . Dr. rer. nat				
	Course			e name			Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-00-0	241-vu	Curve E	stimation			0		Lectur Exerci		6
2		Conten y estima		1 error, kerne	el esti	mate	e, universal o	consister	ıcy, rat	e of co	nvergence,

data-dependent choice of parameters), regression estimation with fixed design (least squares estimates, application of empirical process theory), regression estimation with random design (local averaging, least squares estimates, universal consistency, optimal rate of convergence, data-dependent choice of parameters)

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop an advanced level of understanding of the theory and methods of curve estimation
- are able to extend their knowledge in this field
- are able perform supervised research in this field

4 Requirements for Participation

recommended: Probability Theory, Mathematical Statistics

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Devroye: A Course In Density Estimation.

Devroye, Lugosi: Combinatorial methods in density estimation.

 $Gy\"{o}rfi,\,Kohler,\,Krzyzak,\,Walk:\,A\,\,distribution-free\,\,theory\,\,of\,\,nonparametric\,\,regression.$

van de Geer: Empirical Processes in M-Estimation.

10 Comment

recommended: Mathematics: Master (sto)

Mo	dule na		_			_	_				
no. 04-1	dule			Morkload 150 h	Self	-study	Duration 1 Semen		Frequ Every semes	2.	
	guage o	of Instru	action			son respons . Dr. rer. na					
1	Course	es of the		le e name		Workload (CP) Form of Control Teaching House					
	04-00-0)259-vu		natical Foundations on the contract of the con	of	0		Lectur	re and ise	3	
2	Study Content operational semantics, denotational selection of functional programs					es, domain th	neory, lo	gical r	elations	S,	
3	obtaini of Requir	the ker	c knowle rnel lang for Par	edge of operationa guage LCF rticipation	l and	l denotation	al semar	ntics			
5	Form o	of Exam	ination								
	•		e Exam	ination (Technical) ination (Study Exa		•					
6	Requir	ements	on the	Award of Credit	Poin	ts					
7	Gradir Final M	Iodule I Modul		ination (Technical	Exai	nination, Te	chnical I	Examir	nation,	Weight:	

	Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
9	Literature T. Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific (2006)
10	Comment

Mod	dule na	me										
	Matl	nemati	cal Fou	ndations of Fund	tion	al Program	ming 1					
no. 04-1	dule 10- 7/en	Credit	Points 5 CP	Workload 150 h		- study 105 h	Duration 1 Sement		Frequency Irregular			
	guage o	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher							
1	Course	es of the		le e name					Form of Con Feaching Hou per Wee			
	04-00-0245-vu Mathematical Foundation Functional Programming					0		Lectur Exerci	-	3		
2	operati	Contentional ser	nantics,	denotational sem	antic	s, domain th	neory, lo	gical r	elations	, logic of		
3	Learning Outcomes Students know the basic techniques of operational and denotational semantics. They can use the main methods for proving functional programs correct. They master logical relations e.g. for proving computational adequacy. They know how to solve recursive domain equations.											
4	-			ticipation action to Mathema	atical	Logic						
5	Form o	of Exam	ination	l								

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

T. Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific (2006)

10 Comment

recommended: Mathematics: Master (log)

Mod	lule na	me									
	Math	nematio	al Fou	ndations o	of Fund	tion	al Program	ming 2			
no. 04-1	lule 10- 8/de	Credit	Points 5 CP	Workload	150 h		study 105 h	Duratio 1 Semes		Frequei Every 2. semeste	
	guage c man	of Instru	ıction				on respons Dr. rer. nat				
1	Course	es of the	Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week

	04-00-0260-vu Mathematical Foundations of 0 Lecture and 3 Exercise
2	Study Content full abstraction, computability in domains
3	Learning Outcomes systematic understanding of the relation between operational and denotational models. extension of the notion of computability to domains.
4	Requirements for Participation Mathematische Grundlagen der funktionalen Programmierung 1
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed) • Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module
9	Literature T. Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific (2006)
10	Comment

Module name

Mathematical Foundations of Functional Programming 2

Teaching Hour per					T			1		<u> </u>	
Language of Instruction Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher	no. 04-1	0-	Credit				•			_	•
Course no. Course name Workload (CP) Form of Teaching Gont Hour per Weel 04-00-0246-vu Mathematical Foundations of Functional Programming 2 0 Lecture and Exercise 2 Study Content Full abstraction, computability in domains 3 Learning Outcomes Students can prove basic facts about recursive domain equations. They understand the notion of full abstraction and understand how to construct a fully abstract model for P using Kripke logical relations. Moreover, they know basic facts about computability in domains and which extensions of PCF allow to denote all computable elements. 4 Requirements for Participation recommended: Mathematical Foundations of Functional Programming 1 5 Form of Examination Final Module Examination: • Module Examination (Technical Examination, optional, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective num of students taking the exam. 6 Requirements on the Award of Credit Points Passing the Fachprüfung 7 Grading Final Module Examination: • Module Examination (Technical Examination, optional, Weight: 100%, Standard) 8 Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics	Lang	guage o	of Instru	action			_				
Teaching			es of the	e Modu	le	-					
Functional Programming 2 Exercise		Course	e no.	Cours	e name		Workload	(CP)			Contact Hours per Week
full abstraction, computability in domains Learning Outcomes Students can prove basic facts about recursive domain equations. They understand the notion of full abstraction and understand how to construct a fully abstract model for P using Kripke logical relations. Moreover, they know basic facts about computability in domains and which extensions of PCF allow to denote all computable elements. Requirements for Participation recommended: Mathematical Foundations of Functional Programming 1 Form of Examination Final Module Examination: Module Examination (Technical Examination, optional, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective num of students taking the exam. Requirements on the Award of Credit Points Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, optional, Weight: 100%, Standa Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics		04-00-0)246-vu			of	0				3
Students can prove basic facts about recursive domain equations. They understand the notion of full abstraction and understand how to construct a fully abstract model for P using Kripke logical relations. Moreover, they know basic facts about computability in domains and which extensions of PCF allow to denote all computable elements. 4 Requirements for Participation recommended: Mathematical Foundations of Functional Programming 1 5 Form of Examination Final Module Examination: • Module Examination (Technical Examination, optional, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective num of students taking the exam. 6 Requirements on the Award of Credit Points Passing the Fachprüfung 7 Grading Final Module Examination: • Module Examination (Technical Examination, optional, Weight: 100%, Standa Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics	2	•			utability in domai	ns					
recommended: Mathematical Foundations of Functional Programming 1 Form of Examination Final Module Examination: • Module Examination (Technical Examination, optional, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective num of students taking the exam. Requirements on the Award of Credit Points Passing the Fachprüfung Grading Final Module Examination: • Module Examination (Technical Examination, optional, Weight: 100%, Standard Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics	3	Studen notion using F	its can p of full a Kripke lo	orove ba ibstracti ogical re	on and understan lations. Moreover	d hov , they	v to constru	ct a fully facts ab	abstra	act mod mputal	lel for PCF pility in
 Final Module Examination: Module Examination (Technical Examination, optional, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective num of students taking the exam. Requirements on the Award of Credit Points Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, optional, Weight: 100%, Standa Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics 		_			_	ns of	Functional	Program	ming [1	
Passing the Fachprüfung 7 Grading Final Module Examination: • Module Examination (Technical Examination, optional, Weight: 100%, Standa 8 Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics		Fachpr only a form o commu	Module I Modul üfung: I small nu f an ora inicated ents tak	Examinate Exam Usually umber of the exam. I during the	ntion: ination (Technical the exam is taken of potential partici The decision abou the first two weel exam.	in for pants it the	rm of a writ . In this case form of the the lecture,	ten test, e, the exa exam is	except am car taken	t when 1 be tak and	en in the
Final Module Examination: • Module Examination (Technical Examination, optional, Weight: 100%, Standa 8 Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics	6	_				Poin	ts				
B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics	7		Iodule I			l Exai	mination, op	tional, V	Veight	: 100%	, Standard)
9 Literature	8		•			.Sc. N	lathematics				
<u> </u>	9	Literat	ure								

	T. Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific (2006)
10	Comment
	recommended: Mathematics: Master (log)

	Sum	marizir	ng a Ma	athematical	Lecti	ıre (single)			Г	
no. 04-1	dule 10- 2/de	Credit	Points 1 CP	Workload	30 h	Self	- study 30 h	Duratio 1 Semes		Frequency Every 2. semester	
	guage o	of Instru	action				on respons liendekan*ii				
1	Course	es of the	e Modu	le							
	Course	e no.	Cours	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0	0261-pj	Summa Lecture	rizing a Mathe (single)	ematic	al				Accompanyin 0 g Self-study	
2		Contending on									
3	Die Studie we	sentlich	len kön en Verst nvortrag	nen aus einer ändnisschwi g in eigenen V zieren	erigke	eiten	identifiziere	n, aufklä	iren		rag
4	_			r ticipation er Mathemati	k						
5	_	of Exam									
	•	Modul Passed		ination (Stud	ly Exa	mina	ition, Study	Examina	ition,	Passed /	Not
		Requirements on the Award of Credit Points									

7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)
8	Usability of the Module Bachelor Mathematik
9	Literature
10	Comment Verantwortlich: Studiendekan

Module name											
	Summarizing a Mathematical Lecture (single)										
Module no. 04-10- 0252/en		Credit Points		Workload	30 h	Self	-study 15 h	Duratio 1 Seme	Every 2		
Language of Instruction English							son respons liendekan*ii				
1	Course	es of the	e Modul	le							
	Course no. Course nam		e name	Workload		(CP)	Form of Teaching		Contact Hours per Week		
	04-00-0	242-pj	Summa Lecture	rizing a Mathe (single)	ematic	al	0		Accompanyin g Self-study		1
2	•	Contential									
3	Learning Outcomes Die Studierenden können aus einem anspruchsvollen mathematischen Fachvortrag die wesentlichen Verständnisschwierigkeiten identifizieren, aufklären und einen Fachvortrag in eigenen Worten formulieren und schriftlich gut verständlich kommunizieren										
4	-			ticipation r Mathemati	k						

5	Form of Examination
	Final Module Examination:
	Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading
	Final Module Examination:
	Module Examination (Study Examination, Study Examination, Weight: 100%,
	Passed / Not Passed)
8	Usability of the Module
	Bachelor Mathematik
9	Literature
10	Comment
10	Verantwortlich: Studiendekan

Mod	Module name										
	Summarizing a Mathematical Lecture (double)										
Module no. 04-10- 0253/de		Credit Points 2 CP		Workload 60		f-study 60 h	Duration 1 Semester		Frequency Every 2. semester		
	Language of Instruction German					Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Course	es of the	e Modul	le							
	Course no. Course name					Workload	(CP)	Form Teac		Contact Hours per Week	
	04-00-0262-pj Summarizing a Mathematical Lecture (double)		ical	0		Accompanyin g Self-study		0			
2		Contending on									

3	Die Studierenden können aus einem anspruchsvollen mathematischen Fachvortrag									
	die wesentlichen Verständnisschwierigkeiten identifizieren, aufklären und einen Fachvortrag in eigenen Worten formulieren und schriftlich gut									
	verständlich kommunizieren									
4	Requirements for Participation									
	Arbeitstechniken in der Mathematik									
5	Form of Examination									
	Final Module Examination:									
	 Module Examination (Study Examination, Study Examination, Passed / Not Passed) 									
6	Requirements on the Award of Credit Points									
7	Grading									
	Final Module Examination:									
	Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)									
8	Usability of the Module									
	Bachelor Mathematik									
9	Literature									
10	Comment									
	Verantwortlich: Studiendekan									
<u></u>										

Module name											
Summarizing a Mathematical Lecture (double)											
Mod no. 04-1 0253		Credit	Points 2 CP	Workload	60 h		study 30 h	Duratio 1 Semes		Frequer Every 2. semeste	·
Lan	guage (of Instru	action			Pers	on respons	ible for 1	the M	odule	
Eng	lish					Stud	iendekan*ii	n des Fac	hbere	ichs 04	
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form	n of	Contact

				Teaching	Hours per Week			
	04-00-0243-pj	Summarizing a Mathematical Lecture (double)	0	Accompanyin g Self-study	2			
2	Study Contendepending on							
3	die wesentlich	len können aus einem anspruc en Verständnisschwierigkeiten hvortrag in eigenen Worten fo	identifizieren, aufkl	iren	rag			
4	_	s for Participation en in der Mathematik						
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed)							
6	Requirements	s on the Award of Credit Poir	nts					
7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)							
8	Usability of the Bachelor Math							
9	Literature							
10	Comment Verantwortlich	n: Studiendekan						

Modu!	le	name
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Operatoralgebras and Noncommutative Probability

Module no.Credit PointsWorkloadSelf-studyDuration04-10- 02589 CP270 h180 h1 Semeste		1 2		•						
	guage o man and					on respons . Dr. rer. na				r
1	Course	es of the	e Modul	le	l					
	Course no.		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)252-vu		ralgebras and nmutative Probabilit	y	0		Lectur Exerci		6
2 Study Content Bell inequalities and mathematical foundations of quantum mechanics, tensor products, trace class operators and the algebra of all bounded operators on a Hillbert space, operator topologies, von Neumann algebras, normal states and representations, basic notions of quantum probability (Gleason's Theorem, probability spaces, compound systems, random variables, conditional expectations, transition operators), stationary Markov processes and examples from physics.							ice, , basic und			
3	Learning Outcomes Students are able to use Bell's inequality for distinguishing classical physics from quantum mechanics, to define and interpret tensor products, to distinguish various topologies on von Neumann algebras, to construct normal states with corresponding representations, finally they are able to transfer the basic notions of probability theory, such as random variable, conditional expectation, transition operator, Markov process, to the operator algebraic context and to illustrate them in physically relevant examples.									
4	recomi		: Functio	rticipation onal analysis, basi	c kno	wledge of sp	pectral th	neory a	and qua	antum
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are									
	form of	f an ora inicated	l exam.	f potential particip The decision abou the first two week exam.	t the	form of the	exam is	taken	and	
6	Requirements on the Award of Credit Points Passing the Fachprüfung									

7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature R. V. Kadison, J.R. Ringrose: Fundamentals of the Theory of Operator Algebras I,II. M. Takesaki: Theory of Operator Algebras I. Skripte aus B. Kümmerer, H. Maassen: Probability in Open Quantum Systems, in Vorbereitung.
10	Comment recommended: Mathematics: Master (alg, ana)

Mod	Module name									
	Opti	mizatio	n in fu	nction spaces						
	Module no. Credit Points Workload								_	
no. 04-1	0	Credit	Points 5 CP	Workload 150 h	Self	-study	Duratio 1 Semes		Freque Irregula	•
025	-		J GF	130 11		103 11	1 Sellies	otei	irreguia	
Lan	guage o	of Instru	ıction		Pers	son respons	ible for	the M	odule	
Gen	nan and	d Englis	h		Prof	Dr. rer. nat	t. Stefan	Ulbric	:h	
1	Course	es of the	e Modul	le		1				
	Course no. Course		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)253-vu	Optimiz	ation in function sp	aces	0		Lecture and Exercise		3
2	Study Content Differentiation in Banach spaces: Gâteaux- and Fréchet-derivatives; Hahn-Banach theorem, separation theorems; duality theory, minimax theorem, Lagrange duality, Fenchel duality; Lagrange multiplier theorems: Karush-Kuhn-Tucker conditions, regularity conditions of Robinson and Zowe/Kurcyusz									
3	Learning Outcomes Students - know prototypical examples for infinite dimensional optimization methods - can apply essential techniques of convex anlysis									

- know techniques for the analysis of optimization methods in infinite dimensional spaces $\,$
- know and understand basic algorithms for the sollution of infinite dimensional optimization problems

4 Requirements for Participation

recommended: Nonlinear Optimization, recommended: Functional Analysis

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Luenberger: Optimization by Vector Space Methods;

Ekeland, Temam: Convex Analysis and Varational Problems

10 Comment

recommended: Mathematics: Master (opt)

Module Description

Module name

Real	Realizability										
Module no.	Credit Points	Workload	Self-study	Duration	Frequency						
04-10- 0261/de	5 CP	150 h	105 h	1 Semester	Every 2. semester						

	guage of Instr	uction	Person responsible for the Module							
Ger	man		Prof. Dr. rer. nat. Thomas Streicher							
1	Courses of th	e Module								
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0255-vu	Realizability	0	Lecture and Exercise	3					
2	Study Contentrealizability, n	nt nodified Realizability, asse	emblies, tripos, effective	topos						
3	Learning Outcomes Students should get a good understanding of the difference between semantic validity and provability in formal systems. Moreover, they should adopt the technical abilities for proving Goedel's incompleteness theorems and the theorem of Loeb. Requirements for Porticipation									
4	Requirements for Participation Einf. in die Logik									
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed) • Module Examination (Technical Examination, Technical Examination, Standard)									
6	Requirements	s on the Award of Credit	Points							
7	 Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) 									
8	Usability of the Module									
9	Literature Skript online erhältlich									
10	Comment									

Mod	lule na	me								
	Raliz	ability								
no. 04-1	Module no. Credit Po		Points 5 CP	Workload 150 h	Self	- study 105 h	Duratio 1 Seme		Frequency Irregular	
Lan Eng		of Instru	action			son respons . Dr. rer. na				
1	Courses of the Modu			le e name		Workload (CP)		Form Teac	_	Contact Hours per Week
	04-00-0)263-vu	Realizal	oility	0		Lectur Exerci	-	3	
2	Study Content realizability, modified Realizability, assemblies, tripos, effective topos									
3	Learning Outcomes Students understand Kleene's number realzability and can extract realizers from fomal proofs. Moreover, they know the notion of partial combinatory algebra and its most important instances. They get an idea how to interpret various type theories in realizability models.									
4	_			rticipation	atical	Logic				
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)									
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	_		on the	Award of Credit	Poin	ts				

7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature
	lecture notes provided online
10	Comment
	recommended: Mathematics: Master (log)

Mod	Module name									
	Four	ier Ana	lysis		•					
Module no. 04-10- 0263/de		Credit Points 5 CP		Workload 150 h	3		Duration 1 Semester		Frequency Irregular	
	guage o	of Instru	ıction			son respons				
German Prof. Dr. rer. nat. Matthias Hieber										
1	Course no. Cours			e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0	256-vu	Fourier	Analysis		0		Lecture and Exercise		3
2	•			ngular integral ope	eratoi	rs, interpola	tion, Fou	ırier tr	ansform	nation,
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of singular integrals and singular integral operators - are able to recognise the treated concepts in various fields of mathematics.									
4	Requir	ements	for Pa	ticipation						

recommended: Analysis, Gewöhnliche Differentialgleichungen, Complex Analysis.

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated

during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Studienleistung: Usually this means that the student successfully completes a certain proportion of the homework assignments. The precise proportion of necessary assignments and the marking scheme will be communicated by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature

W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999.

- W. Rudin, Real and Complex Analysis, McGraw Hill, 3. Auflage 1987.
- E. Stein, Harmonic Analysis, Princeton University Press.
- L. Grafakos, Classical and Modern Fourier Analysis, Springer.

10 Comment

recommended: Mathematics: Bachelor year 3 (ana)

Mo	dule na	me								
	Four	ier Ana	lysis							
no. 04-	o. Credit Points Work 4-10- 5 CP 263/en		Workload 150 h	Self	- study 105 h	Duration 1 Semester		Frequency Irregular		
Lan	Language of Instruction English					son respons				
1	Course	es of the	e Modul	le	ı					
			e name	Workload ((CP)	Form of Teaching		Contact Hours per Week	
	04-00-0)256-vu	Fourier	Analysis		0		Lectur Exerci		3
2	Study Content Calderon-Zygmund singular integral operators, interpolation, Fourier transformation, multipliers									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of singular integrals and singular integral operators - are able to recognise the treated concepts in various fields of mathematics.									
4	_			-	iffere	entialgleichu	ngen, C	omple	x Analy	sis.
5	Requirements for Participation recommended: Analysis, Gewöhnliche Differentialgleichungen, Complex Analysis. Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									

6	Requirements on the Award of Credit Points
	Passing the Fachprüfung (technical examination);
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature
	W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999.
	W. Rudin, Real and Complex Analysis, McGraw Hill, 3. Auflage 1987.
	E. Stein, Harmonic Analysis, Princeton University Press.
	L. Grafakos, Classical and Modern Fourier Analysis, Springer.
10	Comment
	recommended: Mathematics: Bachelor year 3 (ana)

Mod	Module name									
	Incompleteness of Formal Systems									
Module no. 04-10- 0265/de		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
Lan	guage (of Instru	ıction			on respons				
Gen	nan				Prof	. Dr. rer. nat	. Thoma	s Stre	icher	
1	Course	es of the	Modu	le						
	Course no. Course name		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)258-vu	Incomp Systems	leteness of Formal		0 Lectu Exerc			re and ise	3
2	Study Content Gödel's Incompleteness Theorems, Löb's Theorem, Provability Logic									
3	Learning Outcomes The students - know the difference between validity and provability									

	- are able to prove Gödel's 1st and 2nd incompleteness theorems
	- are familiar with Löb's theorem
	- can assess the scope of formal systems and their limitations.
4	Requirements for Participation Einführung in die Mathematische Logik
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard) • Module Examination (Study Examination, Study Examination, Passed / Not Passed)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
	 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
9	Literature Skript online erhältlich
10	Comment

Module name										
Optimization with partial differential equations										
Module no. 04-10-	Credit Points 5 CP	Workload 150 h	Self-study	Duration 1 Semester	Frequency Irregular					
0279		150 H								
German and	of Instruction d English		Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich							

1	Courses of the Module									
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0276-vu	Optimization with partial differential equations	0	Lecture and Exercise	3					
2	Study Content Weak solutions of partial differential equations; Linear-quadratic problems with control constraints: existence and uniqueness, first-order necessary conditions, adjoint equations; semilinear problems with control constraints: existence, Nemyzkii operators, first-order necessary and second-order sufficient conditions; algorithms: finite elements in optimal control, semismooth Newton methods, SQP methods									
3	Learning Outcomes Students - can formulate optimization problems with partial differential equations as optimalcontrol problems are proficient in the techniques for the theoretical analysis of such problems (existence of solutions, optimality conditions) and can apply these know basic algorithms for the solution of such problems.									
4	Requirements for Participation recommended: Nonlinear Optimization and a course on partial Differential Equations (e.g. PDE classical methods (engineering course), PDE I, Numerical Analysis of PDEs etc.)									
5	Duration Fachprüfung: To only a small not form of an ora	Examination: le Examination (Technical I on 60 min, Standard) Usually the exam is taken in umber of potential participa l exam. The decision about l during the first two weeks	n form of a written test ants. In this case, the e the form of the exam	e, except when xam can be tak is taken and	there are en in the					
6	Requirements Passing the Fa	s on the Award of Credit F chprüfung	Points							
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									

	B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature Tröltzsch: Optimale Steuerung partieller Differentialgleichungen Hinze, Pinnau, M. Ulbrich, S. Ulbrich: Optimization with PDE Constraints
10	Comment recommended: Mathematics: Master (opt)

Mod	Module name									
	Bana	ch and	C*-alg	ebras						
Mod no. 04-1		Credit	Points 9 CP	Workload 270 h			Duration 1 Semester		Frequency Irregular	
0280			<i>)</i> G1	27011		100 11	1 beine	Ster	megui	ai
Language of Instruction German and English						son respons Prof. Dr. re				
1	Course	es of the	e Modu	le						
	Course no. Course na		e name		Workload (CP)		Form Teac	-	Contact Hours per Week	
	04-00-0202-vu Banach and C*-algebras								Lecture and 6 Exercise	
2	Banach theory	for com	as, ideal mutativ	s and homomorph e an non-commute ducible representa	ative	algebras, po	sitivity,	states,	represe	entations,
3	Learning Outcomes Students learn to - understand and explain the basic principles of Banach- and C*-algebras - explain the proofs of basic results in Gelfand theory - apply the theory to basic problems in operator theory									
4	-			rticipation onal Analysis						
5		of Exam Iodule I								

• Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Arveson: An Invitation to C*-Algebras; Davidson: C*-Algebras by Example;

Murphy: C*-Algebras and Operator Theory.

10 Comment

recommended: Mathematics: Master (ana)

Mod	lule na	me									
	Gam	e Theo	ry								
Mod no. 04-1 028		Credit	Points 6 CP	Workload	180 h		study 135 h	Duratio 1 Semes		Freque Every 2 semeste	
	Language of Instruction German Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich										
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0)277-vu	Game T	heory			0		Lectur	e and	3

	Exercise
2	Study Content Non-cooperative games: Two-person-zerosum-games, general two-persongames, n-person-games, three-person-zerosum-games. Cooperative games: Solution concepts: Stable sets, core, tau-value, convex games, applications
3	Learning Outcomes Nach dem Besuch des Mpduls verstehen die Studierenden die Grundkonzepte der kooperativen und nicht-kooperativen Spieltheorie
4	Requirements for Participation Grundkenntnisse in Analysis und linearer Algebra
5	 Form of Examination Final Module Examination: Module Examination (Study Examination, Study Examination, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
	 Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module
9	Literature W. Krabs: Spieltheorie: Dynamische Behandlung von Spielen. Verlag B.G. Teubner 2005
10	Comment

Мо	dule na	me									
	Riem	anniar	Geom	etry							
Mo no . 04- 028		Credit	Points 9 CP	Workload 270 h		- study 180 h	Duration Frequency 1 Semester Irregular				
	guage o					son respons				ckmann	
1	Course	es of the	e Modu	le							
	Teaching Hoper						Contact Hours per Week				
	04-00-0)283-vu	Rieman	nian Geometry		0		Lectur Exerci		6	
3	Manifolds, vector fields; Riemannian metrics, parallel transport on submanifolds; Connections, geodesics, exponential map, Hopf-Rinow theorem, hyperbolic space; Curvature tensor, Myers theorem, Jacobi fields, Hadamard theorem Learning Outcomes Students -have an understanding of the abstraction from submanifolds to manifolds -can describe how parallel transport leads to the notion of an invariant derivative -are able to deal with the technicalities of the curvature tensor										
4	Requir	ements	for Pa	gical and geometri rticipation ential Geometry	c sta	tements with	ı curvatı	ire ass	umptioi	18	
5		Duratio	Examina e Exam		Exai	nination, ora	al / writ	ten Exa	aminatio	on,	

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Lee: Riemannian manifolds, an introduction to curvature Gallot, Hulin, Lafontaine: Riemannian Geometry DoCarmo: Riemannian Geometry
10	Comment recommended: Mathematics: Master (geo)

Mod	lule na	me								
	Bana	ach alge	ebras a	nd numerical an	alysi	S				
Mod no.	lule	Credit	Points	Workload	Self	-study	Duratio	n	Freque	encv
04-1 029			9 CP	270 h			•			
	Language of Instruction German and English Person responsible for the Module Apl. Prof. Dr. rer. nat. Steffen Roch									
1	Course	es of the	e Modu	le		1		T		
	Course no. Course name Workload (CP)		(CP)	Forn Teac	_	Contact Hours per Week				
	04-00-0)285-vu	Banach Analysis	Algebras and Nume	rical	0		Lectur Exerci		6
2	Study Content Finite sections method, stability, algebras of approximation sequences, local principles, spectral approximation, fractal algebras, compact sequences, the algebra of the finite sections method for special classes of operators									
3	Studen - under		to nd expl	ain the basic aspec		the interpla	y betwee	en disc	erete and	i

- translate certain questions of numerical analysis to algebraic problems
- apply techniques from the theory of Banach algebras to solve these problems
- state and prove stability properties of specific numerical methods for specific operators

4 Requirements for Participation

recommended: Functional analysis; basic knowledge in Banach algebras useful

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Böttcher/Silbermann: Introduction to large truncated Toeplitz operators, Hagen/R./Silbermann: C*-Algebras and Numerical Analysis.

10 Comment

recommended: Mathematics: Master (ana)

Module Description

Module name

Mathematical Modelling of Fluid Interfaces

IVIati	Mathematical Modelling of Fluid Interfaces I									
Module no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-10- 0291	5 CP	150 h	105 h	1 Semester	Irregular					

	iguage of Instr			son responsible fo					
Ger	man and Englis	h	Prof	Prof. Dr. rer. nat. Dieter Bothe					
1	Courses of the	e Module							
	Course no. Course name Workload (CP) Form of Teaching pe We								
	04-00-0286-vu	Mathematical Modelling of Fluid Interfaces							
2	quasilinear fre for mass, mon conditions; mon Continuum the	on surfaces; two-phase are boundary problems. Den nentum and species mass; odeling of surface tension, ermodynamics of fluid intenear and non-linear closur	rivati deriv , mas erfac	on of two-phase in ration of local balars s transfer, evapora	tegral balance onces and interfation, condensat	equations acial jump ion.			
3	formulate theformulate theformulate clo		-phas palan pission	e fluid systems ce equations n conditions	fluid systems				
4	_	s for Participation : Analysis, Ordinary Differ	rentia	ıl Equations. Alterr	natively compar	able			
5	Form of Exam Final Module 1								
	• Modul	le Examination (Technical	l Exai	nination, optional,	Standard)				
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.								
6	Requirements Passing the Fa	s on the Award of Credit chprüfung	Poin	ts					
7	Grading Final Module l	Examination:							
	• Modul	le Examination (Technical	l Exai	nination, optional,	Weight: 100%	, Standard)			

8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature R. Aris: Vectors, Tensors and the Basic Equations of Fluid Dynamics, Dover 1962. J.C. Slattery, L. Sagis, ES. Oh: Interfacial Transport Phenomena (2nd ed.), Springer 2006. D.A. Edwards, H. Brenner, D.T. Wasan: Interfacial Transport Processes and Rheology, Butterworth-Heinemann 1991.
10	Comment recommended: Mathematics: Master (ana)

Mod	lule na	me								
	Dist	ributior	ntheory	,						
Mod no. 04-1 029		Credit	Points 5 CP	Workload 150 h		- study 105 h		Duration I Semester Frequency Every 2. semester		2.
Language of Instruction German Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber										
1	Course no. Course name Workload (CP) Form of Teaching Hours per Week									
	04-00-0)288-vu	Distribu	tiotheory	0 Lecture and 3 Exercise			3		
2	topolo	Content gical vec nental se	ctor spac	ces, classes of disti	ributi	ons, Fourier	transfoi	rmatio	n,	
3	Learning Outcomes Nach dem Besuch des Moduls - kennen sie die Begriffe topologischer Vektorraum und lokalkonvexer Raum - können sie mit Distributionen bzw. verallgemeinerten Funktionen rechnen und umgehen - können sie mit Fouriertransformation und temperierten Distributionen umgehen									
4	_			rticipation neorie, Maßtheorie	e					

Form of Examination Final Module Examination: Module Examination (Technical Examination, Technical Examination, Standard) Module Examination (Study Examination, Study Examination, Passed / Not Passed) 6 **Requirements on the Award of Credit Points** Grading 7 Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Usability of the Module BSc.Math. Wahlbereich, MSc.Math. Ergänzungsbereich, MSc.Phys. Ergänzungsbereich, LaG. Ergänzungsbereich 9 Literature W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999. W. Rudin, Real and Complex Analysis, McGraw Hill, 3. Auflage 1987. J. Horváth, Topological Vector Spaces and Distributions, volume I, Addison-Wesley, Reading, Mass., 1966. L. Schwartz, Théorie des Distributions, Hermann, Paris, 1966. F. Treves, Topological Vector Spaces, Distributions and Kernels, Academic Press, New York, 1967. Comment 10

Module na	Module name							
Nun	Numerical and Statistical Methods							
Module no. 04-10-	Credit Points 7 CP	Workload 210 h	Self-study 120 h	Duration 1 Semester	Frequency Every 2. semester			
0300/de					beinester			
Language German	of Instruction		Person respons	ible for the M	odule			

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per	
					Week	
	04-00-0081-vu	Numerical and Statistical Methods	0	Lecture and Exercise	6	
2	method in intersystems of non- computation of Statistics: basis multivariate di	alysis: unnumerical solution	te problems for ODEs, ors robability theory, regnation, confidence in	ression, tervals,	erical	
3	auszuwählen ı	comes rundlegende Aufgabenstellu ind anzuwenden. Fähigkeit s grundlegende Schätzverfah	statistische Auswertur	ngen		
4	_	for Participation und Mathematik 2 und Mat	nematik 3			
5	Form of Example Final Module I Module		xamination, Technica	l Examination,	Standard)	
6	Requirements	on the Award of Credit Po	oints			
7		Examination: e Examination (Technical E Standard)	kamination, Technica	l Examination,	Weight:	
8	Usability of the Module Für B.Sc.ETiT, B.Sc.MEC, B.Sc.CE, B.Sc.IST (PO 2007): Pflicht Für B.Sc.EPE, B.Sc.IST (bis PO 2006), B.Sc.iKT: Pflicht zusammen mit Mathematik 3 als Mathematik B Für M.Ed. Mathematik: PraktischeMathematik (für M.Ed.Math) mit 9 ECTS Für B.Sc.Inf mit 9 ECTS					
	Für M.Ed. Mat	hematik: PraktischeMathem	atik (für M.Ed.Math)	mit 9 ECTS		
	Für M.Ed. Mat	hematik: PraktischeMathem it 9 ECTS	atik (für M.Ed.Math)	mit 9 ECTS		

	II, Teubner Verlag Stuttgart;
10	Comment Verantwortlich: Herr Bothe (ana)

3.7											
IVIO	dule na										
Module no.		ulus III Credit Points				-study	Duration		Frequency Every 2.		
04-10- 0301/de		4 CP		120 h	45 n		1 Semester		semester		
Language of Instruction German						Person responsible for the Module					
1	Course	es of the	e Modu	le	ı						
	Course	e no.	Course name			Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0121-vu		Calculus III (civil engineering)			0		Lecture and Exercise		5	
	a) Firs method b) Seconstate c) Part	1) Differential equations: a) First order ordinary differential equations - existence and uniqueness, numerical methods; b) Second order ordinary differential equations - linear differential equations with constant and variable coefficients, systems of linear differential equations; c) Partial differential equations - classification, product ansatz, Fourier series; 2) Calculus of variations;									
3	Learning Outcomes Im Rahmen des für ihren Studiengang Erforderlichen sollen die Studierenden über Vertrautheit mit den einfachsten Typen von Differentialgleichungen erlangen. Die Studierenden besitzen die Fähigkeit, die wichtigsten rechnerischen Methoden in ihrer Bedeutsamkeit beurteilen und auf ingenieurtechnische Fragen, insbesondere im späteren Studium und Beruf anwenden zu können. Sie besitzen Grundvoraussetzungen, sich die benötigten mathematischen Kenntnisse selbst anzueignen.										
4	_	Requirements for Participation gute Kenntnisse in Mathe I und II									

Form of Examination
Final Module Examination:
Module Examination (Technical Examination, Technical Examination, Standard)
Requirements on the Award of Credit Points
Grading
Final Module Examination:
Module Examination (Technical Examination, Technical Examination, Weight:
100%, Standard)
Usability of the Module
Literature
wird zu Beginn der VL bekannt gegeben.
Comment

Mod	lule na	ıme								
	PDE	s on No	nsmoo	th Domains						
Module no. Credit Point 9 C 04-10- 9 C 0303/en 0303/en		Points 9 CP	Workload 270 h			Duration 1 Semester		Frequency Every 2. semester		
	Language of Instruction English Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber									
1	Cours	es of the	e Modu	le						
	Cours	e no.	Course	e name		Workload	(CP)	Form Teac	n of hing	Contact Hours per Week
	04-10-	0308-vu	PDEs or	n Nonsmooth Domai	ns	0		Lectur Exerci	-	6
2										

Learning Outcomes 3 After successfully passing this module students can - formulate and explain the central theorems and methods from the course - apply the methods to elliptic and parabolic partial differential equations and use them to solve adequate problems The students should be able to - evaluate the importance of the results given in the course - contextualise modern mathematical results into the framework of the course **Requirements for Participation** Funktional Analysis or comparable previous knowledge 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, Technical Examination, Standard) Module Examination (Study Examination, Study Examination, Passed / Not Passed) 6 **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Usability of the Module Literature will be announced in the lecture 10 Comment

Module name	

	Asyr	nptotic	s of line	ear evolutionary	equ	ations					
no. 04-1	10- 5 CP 150 h 105 h 1 Semester		Freque Every 2 semest	2.							
Lan g Gerr		of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber						
1	Course	es of the	e Modu	le							
	Course name		e name		Workload	(CP)	Form Teac	_	Contact Hours per Week		
	04-10-0)304-vu		otics of linear mary equations		0		Lectur Exerci		3	
2	Strong		nuous se	emigroups of linea and stability	r ope	rators, evolu	ıtion equ	ations	s, abstra	ct Cauchy	
3	Learning Outcomes After completing the module, students can handle operator semigroups. They can handle abstract linear evolution equations and investigate long-term behaviour of solutions.										
4	_	ements onalana		ticipation							
5		Iodule I Modul	e Exami			·			-		
6	Requir	ements	on the	Award of Credit	Poin	ts					
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) 										
0	Usability of the Module MSc.Math. specialisation, MSc.Math. supplementary area, MSc.Phys. supplementary area, LaG. supplementary area										

9 Literature

Arendt, w., Batty, C.J., Hieber, M., Neubrander, F., Vector-valued Laplace transforms and Cauchy porblems. Birkhäuser, Basel etc., 2001.

Davies, E.B., Obe-parameter semigroups. Academic Press London etc., 1980.

Engel, K.-J., Nagel, R., One-parameter semigroups for linear evolution equations.

Springer, New York etc., 2000.

Lunardi, A., Analytic semigroups and optimal regularity in parabolic problems. Birkhäuser, Basel, 1995.

Pazy, A., Semigroups of linear operators and applications to partial differential equations. Springer, New York etc., 1992.

Tanabe, H., Equations of evolution. Pitman, London etc., 1979.

10 Comment

Module Description

Mo	dule na	me								
	Matl	hemati	cal Mod	delling of Fluid II	nterf	aces II				
Module			Workload		-study	Duratio	n	Freque	ncv	
04-1 030	_		5 CP	150 h		•	1 Semester		Irregula	•
Language of InstructionPerson responsible for the ModuleGerman and EnglishProf. Dr. rer. nat. Dieter Bothe										
1	Course	es of the	e Modu	le	•					
	Course no.		Cours	e name	Workload (CP)		(CP)	Form of Teaching		Contact Hours per Week
	04-10-0)309-vu		natical Modelling of terfaces II		0 Lecture Exercis				3
2	Study Content 1) Balance equations for multiphase fluid systems with interfacial mass; interface momentum and energy balance 2) Mass transfer across fluidic interfaces: chemical potential, interfacial jump conditions 3) Thermodynamically consistent modeling of dynamic three phase contact lines									
3	Studen - descri - formu	ılate the	to anced ple transm	nenomena at fluid hission and thermo						on of

- describe the dissipative processes occuring at three phase contact lines

4 Requirements for Participation recommended: Analysis, Ordinary Differential Equations. Mathematical Modeling of fluid interfaces I

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

I. Müller: Thermodynamics, Pitman 1985

J.C. Slattery, L. Sagis, E.-S. Oh: Interfacial Transport Phenomena (2nd ed.), Springer 2006.

D.A. Edwards, H. Brenner, D.T. Wasan: Interfacial Transport Processes and Rheology, Butterworth-Heinemann 1991.

10 Comment

recommended: Mathematics: Master (ana)

Module name									
Time	series analys	is							
Module no.	Credit Points	Workload		Self-study	Duration	Frequency			
04-10- 0310/de	3 CP		90 h	60 h	1 Semester	Every 2. semester			

	guage of Instruman	uction	Perso	n responsible fo	or the Module					
1	Courses of the	e Module	1							
	Course no. Course name		Workload (CP)		Form of Teaching	Contact Hours per Week				
	04-10-0310-vl	Time series analysis	0		Lecture	2				
2	Study Content Time series models in discrete time annd examples; Time series analysis: Overview, model identification, estimation of parameters, forecasting, spectral analysis									
3	Learning Outcomes Nach dem Besuch des Moduls können die Studierenden -die wichtigsten Grundideen und zentralen Ergebnisse der Zeitreihenanalyse im Rahmen einfacher Zeitreihenmodelle beschreiben, -ausgewählte Methoden der Zeitreihenanalyse mathematisch analysieren und die dabei erlernten Beweistechniken auf verwandte Fragestellungen übertragen.									
4	_	s for Participation die Stochastik, Probability	y Theoi	ry#47;Wahrsche	inlichkeitstheor	rie				
5	Passed]	Examination: le Examination (Study Exa		•	·					
6	Requirements	on the Award of Credit	Points	1						
7	 Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) 									
8	Usability of th	ne Module								
9	Literature									

Schlittgen, R., Streitberg, B.H.J.: Zeitreihenanalyse. Oldenbourg.
Brockwell, P.J., Davis, R.A.: Introduction to Time Series and Forecasting.
Springer.
Falk et al.: A First Course on Time Series Analysis.
http:#47;#47;statistik.mathematik.uni-wuerzburg.de#47;timeseries#47;

10 Comment
Verantwortlich: Stochastik

Mod	dule na	me								
	Class	sical an	d Non-	Classical Model	Γheo	ry				
Module no. Credit P 04-10- 0311/en		Points 9 CP	Workload 270 h		f-study Duration 180 h 1 Seme		-		•	
Language of Instruction English						son respons			odule	
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name	Workload (CP)			Teaching I		Contact Hours per Week
	04-10-0)311-vu	Classica Model T	l and Non-Classical Theory		0		Lectur Exerci	_	6
2	compa proper tractab	ties; Ehr le mode	ics: first renfeucl els; pres	-order and other lont-Fraïssé games a ervation and express finite and algorit	nd Li essive	indstroem the completen	neorems; ess; algo:	tracta	ble theo	ries and
3	Learning Outcomes Students understand and are able to apply and compare core notions, methods and results of classical and of finite model theory treated in the course. They have developed an advanced level of understanding of classical as well as non-classical logical systems in terms of expressiveness, links between syntax and semantics and algorithmic issues, which enables them to extend their knowledge in this field and allows them to conduct related research under supervision.									
4	Requirements for Participation recommended: Introduction to Mathematical Logic. Alternatively: Logic as taught in CS programmes									

Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

Requirements on the Award of Credit Points

Passing the Fachprüfung

Grading

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

Literature

Cori/Lascar: Mathematical Logic Chang/Keisler: Model Theory

Hodges: Model Theory

Poizat: A Course in Model Theory Ebbinghaus/Flum: Finite Model Theory

Grädel et al (eds): Finite Model Theory and Its Applications

10 Comment

recommended: Mathematics: Master (log)

Due to content overlap, this course cannot be combined with Model Theory or Finite

Model Theory.

Module Description

Module name **Game Theory** Module Credit Points | Workload **Self-study** Duration Frequency no. 04-10-5 CP 150 h 105 h 1 Semester Irregular 0312/de **Language of Instruction** Person responsible for the Module

Ger	man		Prof. Dr.	rer. nat. Stefa	n Ulbrich				
1	Courses of the	e Module							
	Course no.	Course name	Woi	kload (CP)	Form of Teaching	Contact Hours per Week			
	04-10-0320-vu	Game Theory	0		Lecture and Exercise	3			
2	Study Content Cooperative game theory: coalitions, solution concepts, stable sets, core, Shapley value, convex games. Non-cooperative game theory: Sequential and strategic games, two-person and n-person games, zero-sum and non-zero-sum games, discrete and continuous games. Various concepts of solution of a game (e.g. Nash equilibrium). Fixed point theorems (e.g. Brouwer). Existence results (e.g. minimax theorem) and impossibility theorems. Algorithmic aspects. Applications.								
3	Learning Outcomes Students are familiar with different aspects of game theory, its use and its limitations. They understand fundamental (solution) concepts in cooperative or noncooperative game theory. They can illustrate and discuss abstract concepts using examples and construct game theoretic models of simple applications. They are able to prove and apply mathematical theorems to analyze games and to judge the results with respect to practical purposes. They can solve certain classes of games numerically.								
4	_	s for Participation : Analysis, Linear Algebra							
5	Form of Exam Final Module I • Modul		Examinat	ion, Technical	l Examination,	Standard)			
	• Modul	le Examination (Study Exa	amination,	Special Form	, Passed / Not	Passed)			
	only a small n	Usually the exam is taken umber of potential particight of lexam. The decision abou	pants. In tl	nis case, the e	xam can be tak				
		t two weeks of the lecture	e, based on	the prospecti	ve number of s	tudents			
	proportion of t	g: Usually this means that the homework assignment and the marking scheme w	ts. The pre	cise proportio	n of necessary				

Requirements on the Award of Credit Points

	Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Osborne: An Introduction to Game Theory Forg, Szép und Szidarovszky: Introduction to the Theory of Games Krabs: Spieltheorie: Dynamische Behandlung von Spielen Berninghaus, Ehrhart und Güth: Strategische Spiele
10	Comment recommended: Mathematics: Bachelor year 3 (opt)

Mod	lule na	me									
	Riem	nann Su	ırfaces								
Module no. C. 04-10- 0314/de		Credit	Points 5 CP	Workload 15	'orkload 150 h		study 105 h	Duration 105 h 1 Semester		Frequency Every 2. semester	
Language of InstructionPerson responsible for the ModuleGermanProf. Dr. rer. nat. Jan Hendrik Bruinier							r				
1	Course	es of the	e Modul	e							
	Course no. Course name						Form Teac	-	Contact Hours per Week		
	04-10-0)314-vu	Rieman	n Surfaces			0		Lectur Exerci		3
2	Study	Conten	t								
	Riemann surfaces, holomorphic maps, the fundamental group, coverings, the universal covering, algebraic functions, differential forms, cohomolgy groups, the Theorem of Riemann-Roch.										

3	Learning Outcomes Students understand the concept of a Riemann surface. They master basic techniques for the study of the geometry of Riemannian surfaces such as coverings, differential forms and cohomology theory.
4	Requirements for Participation Einführung in die Algebra, Funktionentheorie
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed) • Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module Für B.Sc.Math, B.Sc.Math (bilingual), B.Sc.MCS, B.Sc.WiMa, B.Sc.ME: Wahlp#64258;ichtbereich. Für M.Sc.Math: Vertiefungsbereich. Für M.Sc.WiMa: Ergänzungsbereich.
9	Literature O. Forster: Riemannsche Flächen (Riemann surfaces) E. Freitag: Funktionentheorie II K. Lamotke: Riemannsche Flächen H. M. Farkas and I. Kra: Riemann surfaces
10	Comment

Module name

Distributions and Harmonic Analysis

Mod	lule									
no. 04-1		Credit	Points 5 CP	Workload 150	d Self-study Duration 150 h 105 h 1 Semes		Every 2		2.	
	-	of Instru	ıction		Pers	son respons	ible for	the M	odule	
Gen						Dr. rer. na				
1	Course	es of the	e Modu	le		T				
	Course	e no.	Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)316-vu	Distribu Analysis	itions and Harmon s	ic	0		Lecture and Exercise		3
2	Distrib	Contenution classification	asses, F	ourier transforma	ation, l	Fundamenta	l solutio	ns, Sol	oolevspa	aces,
3	Learning Outcomes After completing the module, students will be able to deal with distributions and Sobolev spaces. They understand distributions, Sobolev spaces and the basics of harmonic analysis.									
4	Requir Analysi		for Pa	rticipation						
5		of Exam Iodule I								
	•	Modul Standa		ination (Technica	al Exar	nination, ora	al / writt	en Exa	aminatio	on,
6	_	ements g the Fa		Award of Credi	t Poin	ts				
7	Gradin Final M	ıg Iodule I	Examina	ntion:						
	•			ination (Technica), Standard)	al Exar	nination, ora	al / writt	en Exa	aminatio	on,
8	Usability of the Module BSc.Math. Wahlbereich, MSc.Math. Ergänzungsbereich, MSc.Phys. Ergänzungsbereich, LaG. Ergänzungsbereich									
9	Literature W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999. W. Rudin, Real and Complex Analysis, McGraw Hill, 3. Auflage 1987. L. Schwartz, Théorie des Distributions, Hermann, Paris, 1966. W. Walter, Distributionen									

	L. Evans, Partial Differential Equations								
10	Comment								

Мо	dule na	me								
Markov chains an Module no. Credit Points 04-10- 9 CP 0318/de				Self-study		Duratio 1 Seme		Frequency Every 2. semester		
Language of Instruction German					son respons . Dr. rer. nat					
1	Course	es of the e no.		le e name		Workload	(CP)	Forn Teac	n of hing	Contact Hours
	04-10-0)318-vu		chains and interacti				Lectui Exerci	re and	per Week
	Study Content Discrete time Markov chains: stationary distributions, recurrence and transience, convergence towards stationary distributions, variation distance, mixing time, coupling; Examples: random walks on groups, birth and death chains, urn models, card shuffling, Particle systems: Curie-Weiss model, Ising model, thermodynamic limit, phase transitions.									
3	Particle systems: Curie-Weiss model, Ising model, thermodynamic limit, phase									

4	Requirements for Participation
	Analysis, Lineare Algebra und Wahrscheinlichkeitstheorie.
5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Standard)
	Module Examination (Study Examination, Study Examination, Passed / Not
	Passed)
	Passeu)
6	Requirements on the Award of Credit Points
0	Requirements on the Award of Great Foliats
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Weight:
	100%, Standard)
	 Module Examination (Study Examination, Study Examination, Weight: 0%,
	Passed / Not Passed)
	TT 199. C.1 NV 1.1
8	Usability of the Module
	MSc.Math. Vertiefung, MSc.Math. Ergänzungsbereich, BSc.Math. Wahl-
	pflichtbereich, MSc.Phys. Ergänzungsbereich
9	Literature
	D. A. Levin, Y. Peres, E. L. Wilmer: Markov Chains and Mixing Times;
	AMS publishing (2009).
	This publishing (2007).
	J. R. Norris: Markov chains; Cambridge University Press, (1998).
	T. M. Liggett: Interacting Particle Systems, Springer Classics in Mathema-
	tics (2005).
10	Comment

Module name										
Asy	Asymptotics of evolution equations									
Module										
no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-10-	5 CP	150 h	105 h	1 Semester	Irregular					
0319										

Lan	guage of Instru	uction	Per	son responsible fo	r the Module					
Ger	man and Englis	h	Prof	f. Dr. rer. nat. Matt	hias Hieber					
1	Courses of the	e Module	•							
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-10-0319-vu	Asymptotics of Evolution Equations		0	Lecture and Exercise	3				
2	Study Content Stability theory	t y of linear semigroups, Ly	apun	ov method, dichoto	omy, stable ma	nifolds				
3	Learning Outcomes Students learn to apply stability theory, dichotomy, and invariant manifolds									
4	-	Requirements for Participation recommended: Functional Analysis								
	 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 									
6	Requirements Passing the Fac	s on the Award of Credit chprüfung	Poin	its						
7		e Examination (Technical):: 100%, Standard)	Exai	mination, oral / wr	itten Examinat	ion,				
	_	tik, M.Sc. Mathematik, M.	.Sc. N	Mathematics						
9	Springer, New Arendt, w., Ba Cauchy porble	agel, R., One-parameter so York etc., 2000. tty, C.J., Hieber, M., Neub ms. Birkhäuser, Basel etc., nary Differential Equations	rand , 200	er, F., Vector-value 1.	_					

10 Comment

recommended: Mathematics: Master (ana)

Mod	dule na	me								
	Varie	ety of n	nathem	atical tasks (onl	ine)				T	
no. 04-1	dule 10- 2/de	Credit	Points 2 CP	Workload 60 h		-study 60 h	Duratio 1 Semes		Frequency Every 2. semester	
Language of Instruction German					son respons . Dr. phil. na					
1	Course	es of the	e Modul	le			<u> </u>			
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0)322-vl	Variety (online)	of mathematical tasks 0		0		Lecture		0
3	Results of studies to describe competencies of teachers, analysis of tasks in old and new school books, examples from the PISA- and TIMSS-tests, tasks in examinations, tasks for gifted students for the "Tag der Mathematik" or other competitions Learning Outcomes Die Studierenden können das Lernpotenzial unterschiedlicher Aufgabenformate an Beispielen in Lern- und Testsituationen beschreiben und entwickeln Problemlösekompetenz. Schulmathematische Kenntnisse werden in Erklärungssituationen vertieft und vernetzt.									
4	_			rticipation eminar (auch para	llel b	elegbar)				
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Study Examination, Passed / Not Passed)									
6	Requir	ements	on the	Award of Credit	Poin	ts				

7 Grading

Final Module Examination:

 Module Examination (Study Examination, Study Examination, Weight: 100%, Passed / Not Passed)

8 Usability of the Module

Stand SoSe2012: Im Wahlpflichtbereich als Alternative zur Schulpraktischen Erprobung (2 CP) in Verbindung mit dem Fachdidaktischen Projekt

9 Literature

Online-Skript, Ergebnisse und Materialien von Schulleistungsstudien, Abiturprüfungen und Mathematikwettbewerben, gängige Lehrbücher

10 Comment

In der Novelle des Studien- und Prüfungsplanes (gültig ab WS 2012#47;13) verwendbar als Pflichtteilmodul im Modul "Grundlagen des Lehrens und Lernens von Mathematik"(10 CP);

Für Studierende älterer Studienordnungen ersetzt dieses Teilmodul die für das Projektmodul früher geforderten 2 CP Schulpraktische Studien.

Module Description

Mod	Module name										
	Advanced Applied Proof Theory										
Module no. Cred 04-10- 0324/en		Credit	Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular		
Language of Instruction English						Person responsible for the Module Prof. Dr. phil. nat. Ulrich Kohlenbach					
1	Course	es of the	e Modul	le							
	Course no. Course name			Workload	(CP)	Form Teac	-	Contact Hours per Week			
	04-10-0324-vu Advanced Applied Proof Th			eory 0		Lecture and Exercise		3			
2	Study Content This course is a continuation of the course `Basic Applied Proof Theory' and corresponds taken together with the latter with the 4+2 hours course `Applied Proof Theory'. The										

course develops the Gödel functional interpretation of full analysis (Spector), monotone interpretations of analysis and their extensions to systems based on classes of abstract (nonseparable) metric, hyperbolic and normed spaces. In applications to concrete proofs

in mathematics we apply these techniques to analyze proofs in the areas of

approximation theory, metric fixed point theory and ergodic theory. These applications are concerned with the extraction of effective bounds and new qualitative uniformity results from prima facie ineffective proofs.

3 Learning Outcomes

Students

- 1) understand Spector's extension of Gödel's functional interpretation to full analysis by means of bar recursion as well as its monotone version;
- 2) have experience with the inclusion of abstract metric, hyperbolic and normed structures as new base types into the functional interpretation and understand the corresponding logical metatheorems;
- 3) can on their own apply such metatheorems to suitable noneffective proofs, in particular in the area of nonlinear analysis (e.g. in the context of a master thesis) and in this way obtain new effective uniform bounds.

4 Requirements for Participation

recommended: Basic Applied Proof Theory

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Kohlenbach, U.: Applied Proof Theory: Proof Interpretations and Their Use in Mathematics. Springer Monograph in Mathematics, xx+536pp., 2008

10 Comment

recommended: Mathematics: Master (log)

Due to content overlap, this course cannot be combined with Applied Proof Theory.

Module name										
	Com	putabi	lity in A	Analysis						
no. 04-1	Module		Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular	
Lan Eng	guage o lish	of Instru	uction			son respons . Dr. phil. na				
1	Course	es of the	e Modu	le						
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-10-0)325-vu	Comput	ability in Analysis				Lectur Exerci		3
	Foundations and limits of discrete and real computability; Examples of computable and incomputable real numbers, sequences, functions, relations, and sets; Representations and Type-2 Theory of Effectivity (TTE); Computability of operators; Benefit of discrete advice;									
3	Studen They cand als	an refin o know	listingui e exister exampl	sh heuristic numer nce theorems from es of noncomputa pological propertie	anal ble p	lysis in term	s of com	putabi	lity state	ements
4	recomi	nended	: Introd	rticipation uction to Computa taught in CS prog	•	•				
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination,									
	•			ination (Technical) in, Standard)	Exar	mnation, ora	ai / Writt	en Exa	ammatic	911,
	_	_	-	the exam is taken f potential particip				_		

form of an oral exam. The decision about the form of the exam is taken and

	communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature Weihrauch: Computable Analysis (2000)
10	Comment recommended: Mathematics: Master (log)

Module name											
Geometric Combinatorics											
Module no. 04-10- 0327		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular		
						-	nsible for the Module ndreas Paffenholz				
1	Courses of the Module										
	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per Week			
	04-10-0)327-vu	Geomet	ric Combinatorics		*		Lecture and Exercise		3	
2	Study Content This module features recent topics in geometric combinatorics, in particular from the fields of geometry of numbers, polyhedral theory, Ehrhart theory, toric geometry and introduced key algorithms in these fields. It is a goal to relate known methods from combinatorial optimization to a wider range of geometric concepts.										

3 Learning Outcomes

After completion of the module students know about and understand methods and results from the field of geometric combinatorics and their relation to combinatorial optimization, can apply them and can assess their limitations. They are able to extend their knowledge in this field and perform supervised research.

4 Requirements for Participation

recommended: Introduction to Optimization, preferably also Discrete Optimization

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Dimitris Bertsimas und Robert Weismantel, Optimization over Integers, Dynamic Ideas, (2005).

Rekha Thomas, Lectures in geometric combinatorics, AMS (2005).

Alexander Barvinok, A Course in Convexity, AMS (2002)

Jesus De Loera, Raymond Hemmecke, Matthias Köppe, Algebraic and Geometric Ideas in the Theory of Discrete Optimization, SIAM (2012)

Bernd Sturmfels, Gröbner bases and convex polytopes, AMS (1995).

10 Comment

recommended: Mathematics: Master (opt)

Module name

Optimization in Transport and Traffic

Module no. 04-10- 0330	Credit Points 5 CP	Workload 150 h	Self-study 105 h		Frequency Irregular		
Language o	of Instruction		Person responsible for the Module				
German and	d English		Prof. Dr. rer. nat. Marc Pfetsch				

1 | Courses of the Module

dourses of the Module									
Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
04-10-0330-vu	Optimization in Transport and Traffic	0	Lecture and Exercise	3					

2 Study Content

Introduction into the planning of transport and logistics (strategic planing, operative planning, online planning)

- models for public and freight transport (network design, line planning, timetabling, vehicle and duty scheduling)
- modeling techniques (set partitioning, vehicle routing, multicommodity flow, Chvatal-Gomory inequalities, etc.)
- Computational complexity
- Optimization methods column generation
- models for car traffic (dynamic flows, equilibria, Braess-paradoxon etc.) Possible societal implications will be addressed in the lecture.

3 Learning Outcomes

After attending this course, studens will know basic optimization problems in traffic and transport. They will master fundamental optimization methods (modelling, column generation, ...) and will be able to independently set up optimization models and solution methods.

Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly.

4 Requirements for Participation

recommended: Introduction to Optimization; useful: Discrete Optimization

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature
	lecture notes
10	Comment
	recommended: Mathematics: Master (opt)

Mod	Module name										
Stochastic processes											
Module no. Credi 04-10- 0332/de		Credit	Points 9 CP	Workload 270 h	J		Duration 1 Semester		Frequency Every 6. semester		
Language of InstructionPerson responsible for the ModuleGermanProf. Dr. rer. nat. Frank Aurzada											
1	Course	es of the	e Modu	le							
	Course no. Course			e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)332-vu	Stochas	tic processes		0		Lecture and Exercise		6	
2	Study Content - general theory of stochastic processes: path space, filtrations, existence - Gaussian processes - Markov processes										

- martingales in continuous time
- jump processes: renewal processes, Poisson processes
- Brownian motion: path properties
- stochastic integal
- Ito formula
- Girsanov transformation
- stochastic differential equations

3 Learning Outcomes

- get to know the most important results about stochastic processes in continuous time and about stochastic differential equations
- get to know the most important examples of stochastic processes in detail, like Brownian motion, Poisson process
- understand the most important techniques, like martingale arguments, stopping times, relations to functional analysis
- lay the foundations for more advanced topics in stochastic analysis or many-particle systems

4 Requirements for Participation

Analysis, Lineare Algebra und Wahrscheinlichkeitstheorie. Grundkenntnisse in Funktionalanalysis sind sehr hilfreich. Fachdidaktisches Proseminar (auch parallel belegbar)

5 Form of Examination

Final Module Examination:

• Module Examination (Technical Examination, Technical Examination, Standard)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)

8 Usability of the Module

MSc.Math. Vertiefung, MSc.Math. Ergänzungsbereich, BSc.Math. Wahlpflichtbereich, MSc.Phys. Ergänzungsbereich

9 Literature

Klenke: Wahrscheinlichkeitstheorie

Mörters and Peres: Brownian motion

Oksendal: stochastic differential eugations

10	Comment Verantwortlich: Herr Aurzada (sto)

Mod	dule na										
no.	Module no. Credit Points 14-10- 5 CF			Workload 150 h		-study	Duration 1 Seme	-			
	Language of Instruction German and English				son respons . Dr. rer. na			odule			
1	Courses of the Module Course no. Course				Workload	(CP)	Form Teac		Contact Hours per Week		
	04-10-0)335-vu		natical Modelling of ally Reactive Flows		0		Lectur Exerci	_	3	
	for constitutive equations; closure of the partial momentum balances without or with chemical reactions; relations to the classical theory of irreversible processes; multicomponent diffusion; derivation of the Maxwell-Stefan equations; mass action kinetics and the principle of detailed balance; model reduction via quasi-steady-state approximation										
3	Learning Outcomes Students learn to - derive balances for multi-component-flows - derive differential balance equations from integral forms - understand the entropy principle - derive thermodynamically consistent models for flows as dissipative mechanisms - describe chemical recation kinetics - understand the connections between detailed equilibrium and the entropy principle - understand the connection between Fick diffusion and the Maxwell-Stefan equations										
4	_	nended		rticipation is, Ordinary Differ	entia	l Equations.	Alterna	tively (compara	ıble	
5	Form o	of Exam	ination	 [

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- 8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

- V. Giovangigli: Multicomponent Flow Modeling, Springer 1999.
- S. R. De Groot, P. Mazur: Non-Equilibrium Thermodynamics, Dover 1983.
- R. Taylor, R. Krishna: Multicomponent Mass Transfer, Wiley 1993.

10 Comment

recommended: Mathematics: Master (ana)

Mod	Module name										
	Mathematical Foundations of Quantum Mechanics (for Physicists)										
		Points 5 CP	Workload 150 h		study 105 h	Duration 1 Semester		Frequency Every 2. semester			
	guage (man	of Instru	action		Person responsible for the Module						
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name		Workload	(CP)	Form Teac		Contact Hours per Week	

	04-10-0328-vu Mathema Quantum	atical Foundations of Mechanics	0	Lecture and Exercise	3					
2	Study Content Classical physics versus The axioms of quantum									
	Observables and self-ad		•							
	Stone's Theorem and tin	me dependent Schröd	linger Equation.							
	Composed systems and tensor products.									
	Entangled states and qu	antum information.								
3	Learning Outcomes Nach dem Besuch des M	Moduls können die Sti	udierenden							
	das mathematische Modell der Quantenmechanik erläutern und interpretieren,									
	physikalische Annahmen von ihren mathematischen Konsequenzen unterscheiden,									
	die Angemessenheit mathematischer Methoden in der Behandlung quantenmechanischer Probleme bewerten,									
	die fundamentalen Unte erläutern.	erschiede zwischen kl	assischer Physik und	Quantenmech	nanik					
4	Requirements for Part Die Vorlesungen der ers	_	hre des entsprechenc	len Studiengai	nges.					
5	Form of Examination Final Module Examinat	ion:								
	Module Examin Passed)	aation (Study Examin	ation, Study Examina	ation, Passed	/ Not					
6	Requirements on the A	Award of Credit Poir	nts							
7	Grading Final Module Examinat	ion:								
	Module Examin Passed / Not	nation (Study Examin ssed)	ation, Study Examina	ation, Weight:	100%,					
8	Usability of the Modul Nichtphysikalisches Erg		hübergreifende Lehr	veranstaltung.						

J. v. Neumann: Mathematische Grundlagen der Quantenmechanik
M. Reed, B. Simon: Methods of Modern Physics I.
G.W. Mackey: Mathematical Foundations of Quantum Mechanics.
M. Nielsen, I. Chuang: Quantum Computation and Quantum Information.

Comment
Verantwortlich: NF Kümmerer

Mod	Module name									
	Intro	ductio	n to Ax	iomatic Set The	ory					
no. 04-1			Points 5 CP	Workload 150 h		- study 105 h	Duration 1 Seme		Frequency Irregular	
	guage (of Instru	ıction			son respons . Dr. rer. na				
1	Course no. Course name				Workload (CP) For		Form Teac	_	Contact Hours per Week	
	04-10-0	04-10-0338-vu Introduction to Axiomatic Set Theory		et	-		Lecture and Exercise		3	
2										
3	Learning Outcomes Students master the language and basic methods of set theory like transfinite induction and recursion and basic cardinal (in)qualities. Moreover, they can recognize when the Axiom of Choice is used.									
4	_			rticipation nathematical found	datio	ns in Analys	is and Li	near A	lgebra	

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature

Lecture notes provided online. Further reading: Moschovakis "Notes on Set Theory" (Springer 2006)

10 Comment

recommended: Mathematics: Bachelor year 3 (log)

Module Description

Module name **Introduction to Axiomatic Set Theory** Module **Credit Points | Workload** Duration Frequency no. Self-study 150 h 04-10-5 CP 105 h 1 Semester Irregular 0338/en **Language of Instruction** Person responsible for the Module

Eng	lish		Prof. Dr. rer. nat. Thomas Streicher						
1	Courses of the	e Module							
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-10-0338-vu	Introduction to Axiomatic S Theory	et	0	Lecture and Exercise	3			
2	we explain how known today. 'basic facts abo Furthermore w	the language and the axion this system allows one to the introduce the notions at their arithmetics. We discuss the Axiom of Chew Well Ordering Theorem.	o for	mulate and formaliz dinal and cardinal r	ze mathematic numbers and p	s as it is rove some			
3	Learning Outcomes Students master the language and basic methods of set theory like transfinite induction and recursion and basic cardinal (in)qualities. Moreover, they can recognize when the Axiom of Choice is used.								
4	Requirements for Participation solid mathematical foundations in Analysis and Linear Algebra								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)								
	• Module Examination (Study Examination, Special Form, Passed / Not Passed) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.								
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung								
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)								

	Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	Mathematics: Bachelor year 3 (log)
9	Literature Lecture notes provided online. Further reading: Moschovakis Notes on Set Theory (Springer 2006)
10	Comment

Mod	dule nar	ne								
	PDE I	II.A Co	mplex	Fluids						
no. 04-1	Module no. C 04-10- 0339		Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular	
Lan	guage o	f Instru	ıction		Pers	son respons	ible for	the M	odule	
Ger	man and	l Englisl	h		Prof	Dr. rer. na	t. Matthi	as Hie	ber	
1	Course	s of the	e Modul	le						
	Course no. Co		Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0	339-vu	PDE II.	Complex Fluids		0		Lecture and Exercise		3
2	-	pment a	and anal	ytical treatment o lastic fluids.	f flui	d models wi	th comp	lex str	ess tenso	ors, e.g.
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of complex fluids - are able to extend their knowledge in this field - are able perform supervised research in this field									
4	-			rticipation onal Analysis, Part	ial D	ifferential E	quations	I		

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

lecture notes

10 Comment

recommended: Mathematics: Master (ana) Builds on "Partial Differential Equations I".

Upon approval, contents of two PDE II.X-courses may replace "Partial Differential Equations II" and can be combined with the content from "Partial Differential Equations I" as an "Advanced Course in Analysis".

Combinations of two or more PDE II.X-courses as additional courses require approval, too.

Module name										
Interacting particle systems and statistical mechanics										
Module no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-10- 0341/en	9 CP	270 h	180 h	1 Semester	Every 2. semester					
Language	of Instruction		Person responsible for the Module							

Eng	lish	Pı	Prof. Dr. rer. nat. Volker Martin Betz					
1	Courses of the	e Module						
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-10-0341-vu Interacting particle systems an statistical mechanics		d 0	Lecture and Exercise				
2	Study Conten	t						

Continuous time Markov chanis and jump processes, their generator and associated semigroup.

Feller processes and their generator.

Interacting particle systems: important examples like the contact process, spin systems and the

exclusion process.

Correlation inequalities, monotonicity and coupling arguments, graphical representations, duality.

3 Learning Outcomes

Students will get to know some basic theory of continuous time Markov jump processes. They will learn the infinitesimal description of these processes in terms of generators, and how to reconstruct transition semigroups and eventually the process from its generator.

They will then be introduced to the active field of interacting particle systems. These are stochastic processes where many relatively simple small parts interact and create effects on a greater scale - examples are spreading of diseases or opinions, or magnetization in matter. Models covered will include the ferromagnetic Ising model (modelling magnetism), the contact process (modeling spreading of diseases), and the simple exclusion process.

In the second part of the lecture, we will cover the foundations of statistical mechanics. Mathematically this is to study the equilibrium distributions of some of the particle systems above. We will introduce the thermodynamic limit and the thermodynamic quantities such as pressure and free energy, and their significance for the bulk properties of the interacting particle system.

4 Requirements for Participation

Analysis, Lineare Algebra und Wahrscheinlichkeitstheorie. Grundkenntnisse in Funktionalanalysis sind sehr hilfreich.

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Technical Examination, Standard)
- Module Examination (Study Examination, Study Examination, Passed / Not Passed)

6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
8	Usability of the Module MSc.Math. Vertiefung, MSc.Math. Ergänzungsbereich, BSc.Math. Wahlpflichtbereich, MSc.Phys. Ergänzungsbereich
9	Literature Klenke: Wahrscheinlichkeitstheorie (for the basics) Liggett: Continuous time Markov Processes: an introduction; (the first two parts of the lecture will follow chapters 2-4 there). Liggett: Interacting particle systems (a much more in depth book for some background reading). Georgii: Gibbs measures und phase transitions (we will introduce some of the material there in the last third of the course, but with some significant simplifications).
10	Comment Verantwortlich: Herr Betz (sto)

Module name										
Harmonic Analysis										
Module no. Credit Points Workload 04-10- 9 CP 270 1			l f-study 180 h	Duratio 1 Semes		Frequency Irregular				
Language of Instruction German and English						Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber				
1	Courses of the Module									
	Course	Course no. Course name			Workload	Vorkload (CP) Form		n of hing	Contact Hours per	

					Week				
	04-10-0342-vu	Harmonic Analysis	0	Lecture and Exercise	6				
2	Study Content Fourier transformation in Lebesgue-spaces, basic notions of distribution theory, maximal functions, Calderon-Zygmund theory of singular operators, Fourier multiplicators, Littlewood-Paley decomposition								
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of evolution equations - are able to extend their knowledge in this field - are able perform supervised research in this field								
4	_	s for Participation : Functional Analysis							
5	 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 								
6	Requirements Passing the Fac	on the Award of Credit	Points						
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)								
8	Usability of th B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M	.Sc. Mathemati	ics					
9	Literature E.M. Stein Haremonic Analysis, Princeton University Press 1993 L. Grafakos: Classical Fourier Analysis, Springer 2008								
10	Comment recommended:	: Mathematics: Master (a)	na)						

Mo	dule na		00KV 2K	nd Operator Alar	hra	-				
Module		-	Workload 270 h	Self	-study	Duratio 1 Seme		Frequency Irregular		
	Language of Instruction German and English				Person responsible for the Module Prof. Dr. rer. nat. Burkhard Kümmerer					
1	Course	es of the	e Modu	le						
	Course no.		Cours	rse name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)344-vu	Spectra Algebra	l Theory and Operat s	or	0		Lecture and Exercise		
	types of spectra, measure theoretical aspects of spectral theory and representation operators on Hilbert spaces by multiplication operators, positivity, states, GNS-construction and representations of operator algebras, tensor products, compact operators, examples of C*-algebras.									
3	Learning Outcomes Students are able to compare various approaches to spectral theory, to integrate spectral theory for operators on Hilbert spaces into the operatoralgebraic spectral theory, to explain the basic notions and results in the theory of commutative and non-commutative operator algebras, to apply basic techniques from operator algebras, to construct and compare representations of operator algebras.									
4	Requirements for Participation recommended: Functional analysis									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
	Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written									

test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam

	is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	W. Arveson: An Invitation to C*-Algebras
	J.B.Conway: A Course in Functional Analysis
	V. Jones: Von Neumann Algebras. Vorlesungs-Skript, im Internet unter http://math.berkeley.edu/~vfr/math20909.html
	G. Murphy: C*-Algebras and Operator Theory
	M. Takesaki: Theory of Operator Algebras 1
10	Comment
	recommended: Mathematics: Master (alg)

Mod	Module name										
	Vert	ex Alge	bras								
Module no. 04-10- 0345		Credit	Points 5 CP			Self-	study 105 h	Duration 1 Semester		Frequency Irregular	
				Person responsible for the Module Prof. Dr. rer. nat. Nils Scheithauer							
1	Course no. Course name			Workload (CP)		Form of Teaching		Contact Hours per Week			
	04-10-0345-vu Vertex Algebras						Lectur Exerci		3		
2	Study	Conten	t								
	Definit	ion and	propert	ies of vertex a	algeb	ras, 1	attice verte	x algebra	as, affii	ne verte	X

	algebras, introduction to the representation theory, possibly orbifold theory and monstrous moonshine
3	Learning Outcomes The students are familiar with the definition and properties of vertex algebras and know the main examples. Furthermore they know the basic concepts of their representation theory.
4	Requirements for Participation recommended: Algebra
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination,
	Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Kac: Vertex algebras for beginners, AMS Frenkel, Ben-Zvi: Vertex algebras and algebraic curves, AMS
10	Comment recommended: Mathematics: Master (alg) Selected topic in Lie algebras

Module name

	Ellip	tic curv	es and	modular forms						
Mod no. 04-1	lule			Workload 150 h		- study 105 h	Duratio 1 Semes		Freque Every	2.
Lan Geri		of Instru	uction			son respons . Dr. rer. nat				r
1	Course	es of the	e Modu	le	l					
	Course	e no.	Cours	e name	Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)366-vu	Elliptic forms	curves and modular		0		Lectur Exerci		3
2	Study Content Complex tori, the analytic and algebraic theory of elliptic curves, modular forms, Eisenstein series, modular curves, classical conjectures in number theory (e.g. Fermat, Mordell, Birch and Swinnerton-Dyer), applications.									
3	After a	ng Outo ttending odular f	g this co	urse, students will	kno	w the eleme	ntary the	eory of	f elliptio	c curves
4	_		for Partionenth	rticipation eorie						
5	_	Iodule I Modul	e Exam							
6	Requir	ements	on the	Award of Credit	Poin	ts				
7	Gradir Final M	Module I Modul 100%, Modul	Standar	ination (Technical) d) ination (Study Exa					·	C
8		•	ne Modu ul (und	ı le somit auch Ergänz	ungs	bereich im N	Master),	kann a	aber nic	ht im

	Vertiefungsbereich Master eingebracht werden!
9	Literature Fred Diamond, Jerry Shurman: A first course in modular forms. Anthony W.\ Knapp: Elliptic curves. Neal Koblitz: Introduction to elliptic curves and modular forms.
10	Comment

	equa dule			11 1	- 10							
no. 04-1	10-	Credit	Points 5 CP	Workload 150 h	Self-	-study	Duratio 1 Seme		Freque Irregul	•		
036			J GF	130 11	Too ii T beine		stei	integui	aı			
	•	of Instru			Person responsible for the Module							
	German and English Courses of the Module					Prof. Dr. rer. nat. Stefan Ulbrich						
1	Course	es of the	e Modul	le		Γ		1				
	Course	Course no. Cours		e name	Wor		Workload (CP)		n of hing	Contact Hours per Week		
	04-10-0)368-vu	control	cal analysis of optim problems governed lifferential equation	by				Lecture and Exercise			
2	Finite-	ons by tl	onal app he finite	proximation of opt -element method; ble finite-element	a-pri	ori error ana	alysis an	d num				
3	Studer - are proble:	Learning Outcomes Students are proficient in the numerical analysis and solution algorithms for optimization problems subject to partial differential equations. know the specific difficulties in the discretization of such problems.										
4 Requirements for Participation recommended: Nonlinear Optimization and a course on partial Differential E												

(e.g. PDE classical methods (engineering course), PDE I, Numerical Analysis of PDEs etc.) 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 6 **Requirements on the Award of Credit Points** Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics Literature Tröltzsch: Optimale Steuerung partieller Differentialgleichungen S. Brenner, R. Scott: The Mathematical Theory of Finite Element Methods Comment recommended: Mathematics: Master (opt)

Mod	lule na	me									
	PDE	II.D Ev	olution	Equations							
Module no. Credit Points Workload 04-10- 0369 15		150 h		- study 105 h	Duration 1 Semester		Frequency Irregular				
	~ ~	of Instru				Person responsible for the Module					
Geri	man an	d Englis	h			Prof. Dr. rer. nat. Matthias Hieber					
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours

					per Week
	04-10-0369-vu	PDE II.D Evolution Equations	0	Lecture and Exercise	3
2		t perator semigroups, character rial operators, functional calcu			or Lumer-
3	- develop an ac	nd are able to apply the notion dvanced level of understanding tend their knowledge in this form supervised research in this	g of evolution ed ield		the course
4	_	s for Participation : Functional Analysis			
5	Standa Fachprüfung (test, except wh exam can be ta is taken and co	Examination: le Examination (Technical Exa	lly the exam is to the standard of potential am. The decision two weeks of the	aken in form of a v participants. In th about the form of	vritten is case, the the exam
6	Requirements Passing the Fa	s on the Award of Credit Poin chprüfung	nts		
7		Examination: le Examination (Technical Exa :: 100%, Standard)	mination, oral /	written Examinati	on,
8	Usability of the B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M.Sc.	Mathematics		
9	York, 2000 Pazy: Semigro Springer, New	One-parameter semigroups for ups of linear operators and ap York, 1992 Hieber, Neubrander, Birkhäus	plications to par		

10 Comment

recommended: Mathematics: Master (ana) Builds on "Partial Differential Equations I".

Upon approval, contents of two PDE II.X-courses may replace "Partial Differential Equations II" and can be combined with the content from "Partial Differential Equations I" as an "Advanced Course in Analysis".

Combinations of two or more PDE II.X-courses as additional courses require approval, too.

Mod	dule na	me								
	Stoc	hastic p	orocess	es I						
Mod no. 04-1 037		Credit	Points 9 CP	Workload 270		f-study 180 h	Duration 1 Semester		Frequency Irregular	
		of Instru				son respons f. Dr. rer. na				
1		es of the		le	I					
	Course no.		Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0)372-vu	Stochas	tic processes I		0	Lecture and Exercise		6	
2	definit: - Brow gener - Ito in	nian mo al theor tegral	existend otion: de y of Gar	ce of stochastic finition, exister ussian processes l equations	ice and				ete time	
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an intermediate level of understanding of the theory of stochastic processes - are able to extend their knowledge in this field									
4	recomi	nended	: Analys	rticipation is, Linear Algeb unctional analy	-	•	•			

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Klenke: Wahrscheinlichkeitstheorie Mörters and Peres: Brownian motion Lifshits: Gaussian random functions

Karatsas and Shreve: Brownian motion and stochastic calculus

10 Comment

recommended: Mathematics: Master (sto)

Module Description

Module name Stochastic processes IIA Module Credit Points | Workload Self-study **Duration Frequency** no. 04-10-9 CP 270 h 180 h | 1 Semester Irregular 0373 Language of Instruction Person responsible for the Module German and English Prof. Dr. rer. nat. Frank Aurzada **Courses of the Module** 1 Course no. Course name Workload (CP) Form of Contact Teaching Hours

					per Week
	04-10-0373-vu	Stochastic processes IIA	0	Lecture and Exercise	6
2	random measu - random walk - Markov chair renewal proces	e: infinitely divisible distributes, Levy-Ito decompositions: relations to Levy processus in discrete time, elemen	on, stable Levy ses, fluctuation tary theory of	processes, subordinator n theory	S
3	- develop an ac	nd are able to apply the node and are able to apply the node and a contract and their knowledge in the corm supervised research in	nding of the the		
4	_	for Participation : Stochastic Processes I			
5	Standa Fachprüfung (' test, except wheexam can be taken and co	Examination: e Examination (Technical	Jsually the exa number of pot l exam. The de rst two weeks	m is taken in form of a vential participants. In the	vritten is case, the the exam
6	Requirements Passing the Fa	s on the Award of Credit chprüfung	Points		
7		Examination: e Examination (Technical) :: 100%, Standard)	Examination,	oral / written Examinati	on,
8	Usability of th B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M.	Sc. Mathemati	cs	
9		cheinlichkeitstheorie cesses and infinitely divisi	ble distribution	ns	

	Bertoin: Levy processes Protter: Stochastic integration and differential equations
10	Comment recommended: Mathematics: Master (sto)

Mo	dule na	me								
	Арр	lied Ge	ometry							
no. 04-1	dule 10- 5/de	Credit	Points 9 CP	Workload 270 h	Self	- study 180 h	Duratio 1 Seme		1 1	
	~ ~	of Instru d Englis				son respons . Dr. rer. nat			odule	
1	Course	es of the	e Modu	le						
		Cours	e name		Workload (CP) Form of Teaching 0 Lecture and Exercise		-	Contact Hours per Week		
	04-10-0375-vu Applied			Geometry						6
	spline	surfaces	, subdiv	, Bézier curves, B- ision algorithms, s s and triangular m	moo	thing of curv		_		
3	Student - under curves - are all - thoro	rstand b and sur ble to as ughly u	asic ma faces sess the nderstai	thematical princip ir significance for nd the relationship cometric propertie	theo bety	retical and a ween analyti	pplied p cal prop	urpose erties	es of the i	_
4	_			rticipation ntial Geometry						
5	recommended: Differential Geometry							on,		

 Module Examination (Study Examination, Study Examination, Passed / Not Passed)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Hoschek und Lasser, Grundlagen der geometrischen Datenverarbertung, Teubner Prautzsch, Boehm und Paluszny, Bézier and B-Spline Techniques, Springer Peters und Reif, Subdivision surfaces, Springer

Hoschek und Lasser, Grunglagen der geometrischen Datenverarbertung, Teubner Prautzsch, Boehm und Paluszny, Bézier and B-Spline Techniques, Springer Peters und Reif, Subdivision surfaces, Springer

10 Comment

recommended: Mathematics: Master (geo)

Module Description

Module name **Approximation theory** Module no. Credit Points | Workload Self-study Duration Frequency 270 h 04-10-9 CP 180 h | 1 Semester Irregular 0376/de Person responsible for the Module **Language of Instruction** German and English Prof. Dr. rer. nat. Ulrich Reif

1	Courses of the	e Module								
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-10-0376-vu	Approximation theory	0	Lecture and Exercise	6					
2	Bramble-Hilbe Schoenberg-W interpolation,	t proximation theorem, mulert lemma in anisotropic So hitney theorem, natural ar Jackson type theorems, un ines, geometric approximate	bolev spaces, distance s ad canonical spline inte iform stability, orthogo	spline-controll ; rpolant, quasi onality relation	polygon,					
3	Learning Outcomes Students - understand key aspects of linear uni- and multivariate approximations with polynomials and splines - recognise the crucial role of dual functionals for stability and approximation properties - develop an understanding of various methods of approximation and their properties - can apply suitable methods of approximation to concrete problems									
4	_	s for Participation : Applied Geometry								
5	Form of Exam Final Module I									
	 Modul Standa 	le Examination (Technical rd)	Examination, oral / wr	itten Examinati	ion,					
	• Modul Passed	le Examination (Study Exa)	mination, Study Exami	nation, Passed	/ Not					
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	Passing the Fa	s on the Award of Credit le chprüfung; udienleistung is a prerequis		prüfung						
7	Grading Final Module l	Examination:								

Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
 Module Examination (Study Examination, Study Examination, Weight: 0%, Passed / Not Passed)
 Usability of the Module

 B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

 Literature

 de Boor, A Practical Guide to Splines, Springer Schumaker, Spline functions basic theory, Cambridge University Press Höllig, Finite element methods with B-splines, SIAM

 Comment recommended: Mathematics: Master (geo)

Mod	lule na	me								
	Repr	esenta	tion Th	eory						
Module no. 04-10- 0378/de		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
	Language of Instruction German					on respons . Dr. rer. nat				
1	Courses of the Module									
	Course no.		Course name			Workload (CP)			n of hing	Contact Hours per Week
	04-10-0378-vu Represe			entation Theory		0		Lecture and Exercise		3
2	Study Content Complex representations of finite groups, irreducibility, complete reducibility, Maschke's theorem, Schur's lemma, tensor product, symmetric product, wedge product, character theory, group algebra, representations of the symmetric group, arbitrary ground field, division algebras, splitting fields, restriction and induction, modular representations.									
3	Learning Outcomes The students are familiar with the basic results in the representation theory of finite groups over the the complex numbers. They are able to apply the presented methods to									

	representation theoretic problems.
4	Requirements for Participation Lineare Algbra, Algebra, Einführung in die Algebra
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.ScMath: Vertiefungsbereich M.ScMath: Ergänzungsbereich
9	Literature W. Fulton: Representation theory, JP. Serre: Linear Representations of Finite Groups.
10	Comment

Mod	dule na	ıme									
	von	Neuma	nn Alg	ebras							
Module no. 04-10- 0379		Credit	Points 9 CP	Workload	270 h	Self-study Duration 180 h 1 Semester		Frequency Irregular			
	0	of Instru d Englis				Person responsible for the Module Prof. Dr. rer. nat. Burkhard Kümmerer					
1	Cours	es of the	e Modul	le							
Course no. Cour		Course	name			Workload (CP)		(CP) Form (Teach		Contact Hours per Week	

	04-10-0379-vu	von Neumann Algebras	0	Lecture and Exercise	6							
2	- Tensor norms - Toplogies on - Bicommutant - Comparison of von Neuman - Normal represalgebras - Standard reprindex theory of	of von Neumann algebras										
3	Learning Outcomes Students are able to construct von Neumann algebras, to distinguish between various different topologies on von Neumann algebras, to construct normal states with their corresponding cyclic representations, to compare projections, to classify von Neumann algebras, to construct towers of von Neumann algebras, to compute the index of a subfactor, to distinguish between different knots, and to compute knot polynomials.											
4	_	for Participation : Functional analysis, spectra	al theory and operator	algebras								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.											
6	Requirements Passing the Fac	on the Award of Credit Po chprüfung	oints									
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)											
8	Usability of th B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M.Sc	. Mathematics									

9	Literature
	M. Takesaki: Theory of Operator Algebras I. R.V. Kadison, J.R. Ringrose: Fundamentals of the Theory of Operator Algebras I,II. G. Pedersen: C*-Algebras and their Automorphism Groups. V. Jones, V.S. Sunder: Introduction to Subfactors. V. Jones: Subfactors and Knots.
	Vi vonesi vuotetta una ruivesi
10	Comment
	recommended: Mathematics: Master (alg)

Mod	lule na	me										
	Nonlinear Functional Analysis											
Mod no. 04-1 038		Credit Points 9 CP		Workload 270 h	Self-study 180 h		Duration 1 Semester		Freque Every 2 semest	2.		
Lan Engl		of Instru	action			son respons f. Dr. rer. na						
1	Course no. Course			le e name	me Workload		(CP)	Form Teac		Contact Hours per Week		
	04-10-0381-vu Nonlinear Functional Analys				sis	S 0 Lect Exe			e and se	6		
2	Fixed p		eorems;	calculus in Banacl bifurcation theory	_		•	n \$\ma	athbb{F	{}^n\$		
3	transfe compre	ehensio	sical res	sults from Analysis erent methods froi nalysis of bifurcati	n Fu	nctional Ana	alysis for	the so	lution o			
4	_	ements function		rticipation ysis								
5		of Exam Iodule I		-								
	•	Modul Standa		ination (Technical	Exai	mination, ora	al / writt	ten Exa	aminati	on,		

6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.ScMath: Vertiefungsbereich M.ScMath: Ergänzungsbereich
9	Literature A. Ambrosetti, G. Prodi: A primer of nonlinear analysis. Cambridge University Press 1993 K. Deimling: Nonlinear functional analysis. Springer 1974 M. Ruzicka: Nichtlineare Funktionalanalysis. Springer 2004
10	Comment

Mod	Module name										
	Lie Groups										
Module no. 04-10- 0382/de		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Freque Every 2 semeste	2.	
Lan	Language of Instruction Person responsible for the Module										
Geri	man				Prof	Dr. rer. nat	t. Nils Sc	heitha	uer		
1 Courses of the Module											
	Course	e no.	Course name		Workload (CP)			Form of Teaching		Contact Hours per Week	
	04-10-0)382-vu	Lie grou	ıps	0			Lecture and Exercise		3	
2	Study Content Differential Calculus on submanifolds, Lie groups as ``differentiable group", matrix groups, Lie algebra of a Lie group, Lie functor, Lie group-exponential function										
3	Nach d	Learning Outcomes Nach dem Besuch des Moduls \begin{itemize}									

\item sind die Studierenden mit den grundlegenden Definitionen von Lie-Gruppe, Lie-Algebra, Lie-Gruppen-Morphismus, Lie-Funktor, adjungierter Darstellung und Lie-Gruppen-Exponentialfunktion vertraut \item haben die Studierenden einige wichtige konkrete Beispiele von reellen und komplexen Matrizengruppen kennengelernt und können mit ihnen hantieren \item haben die Studierenden einen ersten Einblick in die Theorie (endlichdimensionaler reeller) Lie-Gruppen erhalten und verstanden, wie man solche mit Hilfe von Lie-Algebren untersuchen kann. \end{itemize} **Requirements for Participation** Analysis, Lineare Algebra, Einführung in die Algebra (elementare Gruppentheorie).\ Grundkenntnisse in Topologie sind hilfreich, aber nicht notwendig Form of Examination 5 Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) **Requirements on the Award of Credit Points** 6 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** M.Sc.-Math: Vertiefungsbereich M.Sc.-Math: Ergänzungsbereich Literature \begin{itemize} \item Vorlesungsskript, \item J. Hilgert#47;K.H. Neeb: Lie-Gruppen und Lie-Algebren, Vieweg (1991) \end{itemize} 10 Comment Vertiefungsniveau

Module Description

Module name

	Com	putatio	nal Flu	id Dynamics							
Moo no. 04-1	_	Credit	Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Semes		Freque Irregul	•	
Lan	guage o			<u> </u>		on respons					
1	1	es of the		le	1101	. Dr. Ter. Ha	. buil Gi				
-	Course no.			e name		Workload (CP)		Form Teac	_	Contact Hours per Week	
	04-10-0)384-vu	Comput	ational Fluid Dynan	nics				e and se	6	
2	Study Content Modelling: Reynolds transport theorem; conservation of mass and momentum; Navier-Stokes and Euler equations; boundary conditions; siomplified models; Analysis: weak formulation; existence and uniqueness results for Stokes and Navier-Stokes; Numerics: The finite element method for coercive and non-coercive problems; convergence analysis; convection-diffusion problems; stable discretization for the Stokes problem; numerical tretament of the Navier-Stokes equations;										
3	Learning Outcomes The students understand the basic equations of fluid dynamics, their origin, and elementary properties. They know about the basics results on solvability of these models and about their numerical solution by finite element methods. The students are able to explain, analyse, and implement the finite element methods.										
4	recomi method useful	nended ds courses:	require	rticipation ed: basic knowledg onal Analysis, Part erential Equations		-		-			
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.										
6	Requirements on the Award of Credit Points										

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature D. Braess: Finite Elemente, Springer. D. C. Brenner, L. R. Scott: The mathematical theory of finite element methods, Springer. V. Girault, PA. Raviart: Finite Element Approximation of the Navier-Stokes Equations, Springer. C. Johnson: Numerical solution of partial differential equations by the finite element method, Dover. R. Temam, Navier-Stokes Equations, North-Holland Publishing.
10	Comment recommended: Mathematics: Master (num)

Mod	Module name											
	Monadic Second Order Logic											
no. 04-1			Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequent Every 2 semeste			
Language of Instruction Person responsible for the Module												
Geri	nan				Prof	. Dr. rer. nat	t. Martin	Otto				
1	Courses of the Module											
	Course no. Cours		Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-10-0)385-vu	Monadi	c Second-Order Logi	ic				re and se	3		
2	Study Content monadic second-order logic; composition and game arguments; monadic theories of linear orders; omega-automata; monadic theories of trees; tree automata											
3	Learni	ng Outo	comes									

	Die Studenten können Sachverhalte in monadischer Logik zweiter Stufe formalisieren und sind in der Lage die üblichen Automaten-Konstruktionen durchzuführen. Sie sind fähig, einfache Nichtausdrückbarkeitsresultate zu beweisen.
4	Requirements for Participation Vertrautheit mit Grundbegriffen der Logik, wie sie z. B. in der "`Einführung in die Logik" oder der "`Logik und Grundlagen" vermittelt wird.
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.ScMath: Vertiefungsbereich Logik; Ergänzungsbereich
9	Literature D. Perrin, JE. Pin, \textit{Infinite Words Automata, Semigroups, Logic and Games,} Elsevier, 2004.
	B. Courcelle, J. Engelfriet, \textit{Graph Structure and Monadic Second-Order Logic,} Cambridge University Press, 2012.
	E. Grädel, W. Thomas, T. Wilke, \textit{Automata, Logic, and Infinite Games,} LNCS 2500, Springer, 2002.
10	Comment Vertiefungsniveau

Module name							
Elem	nentary Numb	er Theory (for Te	eaching Degree	s)			
Module no.	Credit Points	Workload	Self-study	Duration	Frequency		
04-10- 0389/de	5 CP	150 h	105 h	1 Semester	Every 4. semester		

	nguage of Instru	ıction	Person responsible for the Module						
	man	11	Proi	f. Dr. rer. nat. Nils	Scheithauer				
1	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-10-0389-vu	Elementary Number Theory (Lehramt)	7	0	Lecture and Exercise	3			
2	Study Content prime numbers, prime factorization, congruences, Fermat's little theorem, RSA- cryptosystem, Legendre-symbol, quadratic reciprocity. Outlook in Gaussian integers, Dirichlet's prime number theorem or Fermat's problem.								
3	Learning Outo Einführung in Probleme.	comes die elementare Zahlenthe	orie 1	und Behandlung e	iniger klassisch	er			
4	Linear Algebra	for Participation without certification of pro	ereqı	uisites is possible)					
5	 Form of Examination Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Module Examination (Study Examination, Special Form, Passed / Not Passed) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 								
6	_	s on the Award of Credit Fachprüfung; Bestehen den ng			llassungsvoraus	ssetzung			
7	 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) 								

8	Usability of the Module Mathematics: Teaching degrees
9	Literature Schmidt: Einführung in die algebraische Zahlentheorie, Springer Bundschuh: Einführung in die Zahlentheorie, Springer Müller-Stach: Elementare und algebraische Zahlentheorie: Ein moderner Zugang zu klassischen Themen, Vieweg Ireland, Rosen: A classical introduction to modern number theory, Springer Apostol: Introduction to analytic number theory, Springer
10	Comment

Mod	lule na	me									
	Mixed-Integer Nonlinear Optimization										
Mod no.		Credit	Points	Workload	orkload Self		-study Duratio		Freque	ency	
04-1 039			5 CP	150 h		105 h	1 Seme	ster	Irregul	ar	
1		of Instru				son respons					
Gerr		d Englis			Prof	Dr. rer. na	t. Marc F	fetsch			
1	Course	es of the	e Modu	le		ı		1		T	
	Course			• •		of hing	Contact Hours per Week				
	04-10-0)390-vu	Mixed-I Optimiz	nteger Nonlinear ation		0		Lecture and Exercise		3	
2	branch convex		und, ou integer	ter approximation optimization prob							
3	Learning Outcomes Students of this course will understand relevant techniques for the solution of nonlinear optimization problems with integrality constraints.										
4	Requirements for Participation recommended: Nonlinear Optimization or Discrete Optimization										
5	Form o	of Exam	ination	l							

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

R. Horst, H. Tuy: Global Optimization: Deterministic Approaches, Springer, 1996. M. Locatelli, F. Schoen: Global Optimization: Theory, Algorithms, and Applications, MOS-Siam Series on Optimization, 2013

10 Comment

recommended: Mathematics: Master (opt)

Mod	Module name									
	Num	erical N	/lethod	s for Partial Dif	feren	tial Equation	ons			
Module no. Credit Points Workload 04-10- 9 CP 270 h						-study 180 h	Duratio 1 Semes		Frequent Every 2. semeste	
	0	of Instru d Englisl				on respons Dr. rer. na			odule	
1	Course	es of the	Modul	le						
	Course	e no.	Course	e name		Workload	(CP)	Form Teac		Contact Hours per Week

	04-10-0391-vu Numerical Methods for Partial 0 Lecture and 6 Exercise
2	Study Content Examples for partial differential equations in applications; Elliptic problems: weak formulation; analysis of elliptic variational problems; Galerkin approximation, finite element methods, error analysis; Parabolic problems: weak formulation, energy estimates, analysis; semi discretization via the Rothe's method and the method of lines;
3	Learning Outcomes The students are able to solve elliptic and parabolic partial differential equations by finite element methods. They understand the basic construction of these methods and are able to analyze and implement them. Students can compare different methods and explain their advantages and limitations.
4	Requirements for Participation recommended: Introduction to Numerical Analysis, Numerical Analysis of Ordinary Differential Equations or similar knowledge as taught in an engineering programme
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Braess: Finite Elemente: Theorie, schnelle Löser und Anwendungen in der Elastizitätstheorie, Springer, 2013. Larsson, Thomee: Partial Differential Equations with Numerical Methods, Springer, 2003. Großmann, Roos: Numerische Behandlung Partieller Differentialgleichungen, Teubner, 2005.

10 Comment

recommended: Mathematics: Master (num)

Mod	dule na	me								
	Num	erical I	Method	ls for Ordinary D	iffer	ential Equa	itions			
Mod no. 04-1 039	Credit Points 10- 9 CP			Self	study	Duration 1 Semester		Frequency Every 2. semester		
	guage (man	of Instr	action			son respons . Dr. rer. nat			odule	
1	Course	es of the	e Modul	le						
	Course no. Cours		Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0)138-vu		cs of Ordinary itial Equations		0		Lectur Exerci		6
	notions bounds conver	s of stab ary-valu gence;	ility; e proble	one-step methods ems: Shooting met ations: Finite diffe	hods	, finite differ	ence me	ethods	, stabilit	
3	Studen	r simple	some b	pasic numerical sol differential equation		_		-		_
4	Requirements for Participation recommended: Analysis, Linear Algebra, Ordinary Differential Equations, Introduction to Numerical Analysis or similar knowledge as taught in an engineering programme.									
5	Form of Examination Final Module Examination:									
	 Module Examination (Study Examination, Special Form, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) 									

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Passing the Fachprüfung; Passing the Studienleistung is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module B.Sc. Mathematik, M.Sc. Mathematics Literature Deuflhard, Bornemann: Numerische Mathematik 2 Stoer, Bulirsch: Numerische Mathematik 2 10 Comment recommended: Mathematics: Bachelor year 3 (num)

Mod	Module name									
	Disco	ontinuc	us Gal	erkin Methods						
Module no. 04-10- 0395		Credit	Points 6 CP	Workload 180 h		-study 120 h	Duration 1 Semes		Freque Irregul	•
		of Instru d Englisl				son respons . Dr. rer. nat				
1	Course	es of the	e Modul	le						
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-10-0	395-vu	Discont	inuous Galerkin		0		Lectur	e and	4

	Methods Exercise									
2										
2	Study Content Theory of Discontinuous Galerkin methods; Boundedness, Stability, Consistency, Approximation; Upwinding, Limiting; INterior Penalty (IP), local DG (LDG), aso.; Implementation and practical examples (e.g. in Matlab)									
3	Learning Outcomes The students learn about the abstract formulation of discontinuous Galerkin methods for partial differential equations of first and second order. They are able to explain and analyse these methods and to apply them to convection dominated and time dependent problems.									
4	Requirements for Participation recommended: required: Introduction to Numerical Analysis or similar knowledge as taught in an engineering programme; useful courses: Numerical Analysis of Partial Differential Equations, Functional Analysis									
5	Form of Examination Final Module Examination:									
	 Module Examination (Technical Examination, oral / written Examination, Standard) 									
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	Requirements on the Award of Credit Points Passing the Fachprüfung									
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics									
9	Literature D. A. Di Pietro, A. Ern: Mathematical Aspects of Discontinuous Galerkin Methods (Book, Springer) B. Riviere: Discontinuous Galerkin Methods for Solving Elliptic and Parabolic Equations (Book, SIAM)									
10	Comment recommended: Mathematics: Master (num)									

Мо	dule na		105							
no. 04-	Module oc. Credit Points 4-10-1396/de 5 CP		Workload 150 h		- study 105 h	Duration 1 Semester		Frequency Every 2. semester		
	iguage (son respons				
	man and				Prof	Dr. rer. nat	t. Jan He	endrik	Bruinie	r
1	Course no. Course		e name		Workload	(CP)	Form Teac	n of hing	Contact Hours per Week	
	04-10-0)396-vu	Elliptic	Curves		0		Lectur Exerci		3
3	Plane projective curves, the group structure of smooth cubic curves, elliptic curves, Mordell's Theorem, the Lutz-Nagell Theorem Learning Outcomes After attending this course, students will be able to apply algebraic methods to geometric problems in the area of projective curves.									
4	Algebra	a,		rticipation gebraischer Zahler	ntheo	rie sind hilfi	reich			
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
6	Requirements on the Award of Credit Points									
7	Gradin Final M	Iodule I Modul		ition: ination (Technical Standard)	Exar	nination, ora	al / writt	ten Ex	aminatio	on,

8	Usability of the Module M.ScMath: Vertiefungsbereich M.ScMath: Ergänzungsbereich
9	Literature Elliptic curves, Anthony W. Knapp\ The arithmetic of elliptic curves, Joseph H. Silverman
10	Comment Vertiefungsniveau

Mod	lule na	me discipli	nary P	roject						
no. 04-1	Module			Workload 60 h		-study 45 h	Duration 45 h		Frequency Irregular	
Language of Instruction German						on respons Dr. rer. na				
1	Course no. Course			le e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0	398-pr	Interdis	ciplinary Project		0		Project 1		1
2	Study Content A team of students of different study programmes (including mathematics) collaborates on an interdisciplinary project with real-life applications. A complex and open-ended problem is treated with mathematical and interdisciplinary methods. The students need to find and defend their own approaches to the problem. Specifically trained members of the participating disciplines provide methodological and scientific support.									
3	Learning Outcomes Students know the value of mathematical reasoning. They can work in interdisciplinary groups and make valuable contributions.									
4	Requirements for Participation none									
5		of Exam Iodule E								

	Module Examination (Study Examination, Special Form, Passed / Not Passed)
	Studienleistung: Giving an oral presentation about the results of the project.
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature
10	Comment recommended: Mathematics: Bachelor year 2

Module name											
Non-Life Insurance Mathematics											
Mod no. 04-1		Credit Points				Self-study		Duration 1 Semester		Frequency Irregular	
050	1/de										
Lan	guage (of Instru	ıction			Pers	on respons	ible for	the M	odule	
Geri	man					Prof	Dr. rer. na	t. Frank	Aurzao	da	
1	Course	es of the	e Modu	le							
	Course no.		Course name				Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0501-vu Non-Life Insurance Mathematics						0			re and ise	3
2	Study Content - collective and individual model of insurances - computation and approximation of the distribution of the total risk - computation of expectation and other parameters of the model - ruin problem and premium computation - estimation methods for distributions - selection effects										

- reservation - risk distribution - re-insurance 3 **Learning Outcomes** Students should get a first impression on the branch of insurance mathematics. The goal is to prepare for later actuarial studies (e.g. when working for an insurance company). The main focus is on classical risk models. Further topics like tarifs, reservation, and re-insurance are touched. **Requirements for Participation** Introduction to Stochastics 5 Form of Examination Final Module Examination: Module Examination (Study Examination, oral / written Examination, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Standard) 6 **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** B.Sc.Math, B.Sc.WiMa: Wahlpflichtbereich Für M.Sc.Math, M.Sc.WiMa: Ergänzungsbereich

9 Literature

Klaus D. Schmidt, Versicherungsmathematik.

Thomas Mack, Schadenversicherungsmathematik.

10 Comment

Verantwortlich: Herr Aurzada (sto)

Mo	dule na	me								
	Harn	nonic A	nalysis	on Abelian Gro	ups					
Module no. 04-10- 0502		Credit Points 5 CP		Workload 150 h	Self	- study 105 h	Duration 1 Semester		Frequency Irregular	
	guage o					son respons . Dr. rer. nat			odule	
1	Course	es of the	e Modu	le	ı					
			e name		Workload	(CP)	Form of Teaching		Contact Hours per Week	
	04-10-0)502-vu	Harmor Groups	nic Analysis on Abelian		0		Lecture and Exercise		3
(LCA) groups. The Haar measure and the dual group with compact-open topol introduced. The Fourier transform on an LCA group is defined and the inversic as well as the Plancherel Theorem and possibly also the Pontryagin Duality The shown. Different applications are then considered (for example partial different equations and Fourier multipliers on LCA groups).							inversio lity The	n formula orem are		
3	Learning Outcomes Students understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of abstract harmonic analysis on locally compact abelian groups - are able to extend their knowledge in this field and are able perform supervised research in this field.									
4	Requirements for Participation recommended: Integration Theory and basic familiarity with Fourier analysis as covered in Real Analysis or Harmonic Analysis									
5										

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam

	is taken and communicated during the first two weeks of the lecture, based on the
	prospective number of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature
	W. Rudin: Fourier Analysis on Groups
10	Comment
	recommended: Mathematics: Master (ana)
	Tocommonaca, matter (ana)

Module name											
Stochastic Finite Elements											
Module no. 04-10- 0504		Credit Points 6 CP		Workload 180 h	Self-study 120 l		Duration 1 Semester		Frequency Irregular		
		of Instru d Englis			son respons . Dr. rer. nat			odule			
1	Course	es of the	e Modul	le							
	Course no.		Course name			Workload (CP)			n of hing	Contact Hours per Week	
	04-10-0	04-10-0504-vu Stochastic Finite Elements		tic Finite Elements		0			re and se	4	
2	Study Content Monte Carlo finite elements, multi level Monte Carlo finite elements, Karhunen Loeve expansion of random fields, stochastic Galerkin methods: formulation, implementation, solution and error estimation, stochastic collocation										
3		ng Outo ts can fo		e elliptic boundary	/ valı	ie problems	with ran	dom d	lata and	explain	

their origin in applications like uncertainty quantification. They know the basic numerical solution strategies based on finite element approximations in space. Students are able to formulate, analyze, and compare different numerical methods and to implement and apply them .

4 Requirements for Participation

recommended: Introduction to Numerical Analysis, Introduction to Stochastics ideally: Numerical Analysis of Partial Differential Equations

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

- G. J. Lord, C. E. Powell, and T. Shardlow. An Introduction to Computational Stochastic PDEs. Cambridge University Press, 2014.
- R. C. Smith. Uncertainty Quantification: Theory, Implementation, and Applications. SIAM Computational Science and Engineering, 2014.
- D. Xiu. Numerical Methods for Stochastic Computations: A Spectral Method Approach. Princeton University Press, 2010.

10 Comment

recommended: Mathematics: Master (num)

Module Description

Module name

	Arak	elov G	eometr	у						
Moo no. 04-1	dule 10-	Credit Points Workload 150				Self-study Duration 105 h 1 Semes			1	
	Language of Instruction German and English					on respons Dr. rer. na				r
1	Course	es of the	e Modu	le						
	Course no.		o. Course name			Workload	(CP)	Teaching		Contact Hours per Week
	04-10-0)506-vu	Arakelo	v Geometry		0	re and se			
2	Study Content Algebraic sets, affine varieties, plane algebraic curves, intersection number; projective algebraic sets, projective varieties, plane projective curves, Bézout's theorem. Arithme surfaces, divisors, classical (finite) intersection number; Arakelov divisors, Greens' function, arithmetic intersection number; diophantine applications.							rithmetic		
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of Arakelov Geometry - are able to extend their knowledge in this field - are able perform supervised research in this field									
4	_	rements nended		rticipation a						
5	5 Form of Examination Final Module Examination:									
	Module Examination (Technical Examination, oral / written Examination, Standard)								on,	
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	_	ements		Award of Credit	Point	ts				
7	Gradir Final N	ng Module I	Examina	tion:						

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature William Fulton: Algebraic Curves. An introduction to algebraic geometry. Robin Hartshorne: Algebraic Geometry Serge Lang: Introduction to Arakelov theory.
10	Comment recommended: Mathematics: Master (alg) Selected topic in arithmetic geometry

Mod	lule na	me								
	Diffe	rential	Geome	etry						
Mod no. 04-1 0507		Credit	Points 9 CP	Workload 270 h		- study 180 h	Every 2	Frequency Every 2. semester		
1		of Instru	ıction			son respons				• 1
Geri					Prof	Dr. rer. na	t. Elena l	Mader	-Baumd	ıcker
1	Course	es of the e no.		e name		Workload	(CP)	Form		Contact
								Teac	hing	Hours per Week
	04-10-0)507-vu	Differen	itial Geometry		0		Lectur Exerci	-	6
2	arc len	operator	curvatu ; princi	re; selected globa pal curvatures, Ga parallel transport,	ussia	n and mean	curvatu	re. Coi	mpatibil	ity
3	Learning Outcomes After having attended this module the students have developed an intuition for curvature of curves and surfaces. They know how to describe surfaces in terms of differential geometry and they understand the difference between intrinsic and extrinsic geometric quantities.									
4	Requir	ements	for Pa	ticipation						

recommended: Analysis, Ordinary Differential Equations, Linear Algebra

Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

Passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

5

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

9 Literature

Bär: Elementare Differentialgeometrie Montiel, Ros: Curves and surfaces

Hoschek, Lasser: Grundlagen der Geometrischen Datenverarbeitung

10 Comment

recommended: Mathematics: Bachelor year 3 (geo), Teaching Degrees

Module na	Module name											
Diffe	rential Geome	etry										
Module no. 04-10-	Credit Points 9 CP	Workload 270 h	•	Duration 1 Semester	Frequency Every 2. semester							

050	7/en										
Lan Eng	guage of Ir lish	nstructio	on			son respons . Dr. rer. na				licker	
1	Courses of	f the Mo	odul	e							
	Course no	o. Con	urse	e name	Workload (CP) Form of Teach				-	Contact Hours per Week	
	04-10-0507	7-vu Diffe	eren	tial Geometry		0		Lectur Exerci		6	
2	Study Content Curves: arc length and curvature; selected global theorems. Surface theory: fundamental forms, shape operator; principal curvatures, Gaussian and mean curvature. Compatibility equations, geodesics, parallel transport, Gauss-Bonnet Theorem. Possibly further topics.										
3	Learning Outcomes After having attended this module the students have developed an intuition for curvature of curves and surfaces. They know how to describe surfaces in terms of differential geometry and they understand the difference between intrinsic and extrinsic geometric quantities.										
4	Requirement recommen			ticipation is, Ordinary Diffe	eretial	Equations, I	Linear Al	gebra			
5	Form of E	ule Exam	nina	tion:							
	• Mo	odule Ex	ami	nation (Study Ex nation (Technica n, Standard)		_					
	test, excep exam can l is taken an	ot when to be taken and comm	here in t unio	al Examination): e are only a smal he form of an or cated during the students taking	l num al exa first tv	ber of poten m. The decis wo weeks of	tial parti sion abou	cipant	s. In thi form of	is case, the the exam	
6	Passing the	e Fachpr	üfur	•			e Fachpr	üfung			
7	Passing the Studienleistung is a prerequisite for taking the Fachprüfung Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)										

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik
9	Literature Bär: Elementare Differentialgeometrie Montiel, Ros: Curves and surfaces Hoschek, Lasser: Grundlagen der Geometrischen Datenverarbeitung
10	Comment recommended: Mathematics: Bachelor year 3 (geo), Teaching Degrees

Mod	lule na	me									
	Nons	smooth	Analy	sis							
Mod no. 04-1 0508		Credit	Points 5 CP	Workload 150 h		- study 105 h	Duratio 1 Seme		Frequency Every 2. semester		
	0	of Instru	ıction		Person responsible for the Module						
Geri	nan				Prof	Dr. rer. na	t. Alexan	dra So	hwartz		
1	Courses of the Module										
	Course	e no.	Course	e name					of hing	Contact Hours per Week	
	04-10-0)508-vu	Nonsmo	ooth Analysis		0		Lectur Exerci		3	
2	Convex subdiff	erential nooth ar	is: conti , epsilor nalysis: :	nuity and differen a subdifferential, c several subdifferen aal cones, coderiva	alcul ntials	us rules, opt (Clarke, Mo	rimality of	conditi	ons, exa	mples	
3		Learning Outcomes Nach Besuch dieses Moduls									
				iden verallgemein enzierbare Funktio		Ableitungsko	onzepte f	ür kor	ivexe un	d	

- beherrschen die Studierenden die dafür existierenden Rechenregeln
- kennen die Studierenden Optimalitätsbedingungen für konvexe und nichtdifferenzierbare Optimierungsprobleme
- verstehen die Studierenden die analytischen Grundlagen von Verfahren für nichtglatte Gleichungen und Optimierungsprobleme

4 Requirements for Participation

Analysis, Lineare Algebra

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, oral / written Examination, Passed / Not Passed)

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, oral / written Examination, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

B.Sc.Math:Wahlpflichtbereich, M.Sc.Math:Ergänzungsbereich

9 Literature

W. Schirotzek: Nonsmooth Analysis

F. Clarke: Optimization and Nonsmooth Analysis

T. Rockafellar: Convex Analysis

- T. Rockafellar and R.Wets: Variational Analysis
- B. Mordukhovich: Variational Analysis and Generalized Differentiation

10 Comment

Mod	lule na	me										
	Auto	morph	ic Form	ns	ı				ı			
Mod no. 04-1	10-	Credit	Points 9 CP	Workload 270 h		-			Freque Irregula	•		
	guage o				Person responsible for the Module Prof. Dr. rer. nat. Jan Hendrik Bruinier							
1	Course	es of the	e Modul	le		1		1				
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week		
	04-10-0)509-vu	Automo	rphic Forms	0		Lectur Exerci		6			
2	Study Content Dirichlet L-functions, modular forms, Eisenstein series, theta series, Hecke operators and L-functions, congruence subgroups, oldforms and newforms, connection with ellpitic curves, automorphic forms for GL(1) and GL(2).											
3	Studen - under - devel	estand a op an in	nd are a	able to apply the noiate level of underseir knowledge in t	stanc	ling of the th						
4	_			rticipation a, Complex Analys	sis							
5		of Exam Iodule I										
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writt	en Exa	aminatio	on,		
	test, ex exam c is take	cept when	en ther aken in t ommuni	al Examination): Use are only a small the form of an oral cated during the firstudents taking the	numi l exai irst tv	ber of poten m. The decis wo weeks of	tial parti sion abou	cipant at the	s. In thi	s case, the the exam		
6	_	ements g the Fac		Award of Credit	Poin	ts						

Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics 9 Literature D. Bump: Automorphic Forms and Representations, Cambridge University Press A. Deitmar: Automorphe Formen, Springer A. Knapp: Elliptic Curves, Princeton University Press M. Koecher, A. Krieg: Elliptische Funktionen und Modulformen, Springer D. Bump et.al.: An Introduction to the Langlands Programm, Birkhäuser J.H. Bruinier, G. van der Geer, G. Harder, D. Zagier: The 1-2-3 of Modular Forms, Springer 10 Comment recommended: Mathematics: Master (alg)

Mod	lule na	me									
	Shim	ıura Va	rieties								
Mod no.	lule	Credit	Points	Workload	Self	-study	Duratio	n	Freque	encv	
04-1	04-10- 0510		5 CP	150 h	•		1 Semester		Irregul	•	
	guage o				Person responsible for the Module Prof. Dr. rer. nat. Torsten Burkhard Wedhorn						
1	l	es of the		le	1101	. 21, 101, 114	1010101	- Dari		canoni	
	Course no. Course na			e name	Workload (CP)			Form of Teaching		Contact Hours per Week	
	04-10-0)510-vu	Shimura	a Varieties		0		Lectur Exerci		3	
2	Study Content Shimura varieties are higher-dimensional generalizations of modular curves. They play a central role in the area of intersection of number theory, geometry, algebra, and analysi Starting with the upper half plane and certain quotients, modular curves, we will study and classify hermitian symmetric domains as generalizations. We will give an interpretations of certain quotients as Shimura varieties. Moreover, it is planned to explain modular forms in this general context.								d analysis. ill study		

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop an advanced level of understanding of the theory of Shimura varieties
- are able to extend their knowledge in this field
- are able perform supervised research in this field

4 Requirements for Participation

recommended: Algebra, Topology (useful)

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

- S. Helgason: Differential Geometry, Lie groups, and symmetric spaces. Academic Press 1978
- S. Kobayashi, K. Nomizu: Foundations of differential geometry I+II, Wiley Classics Library 1996

10 Comment

recommended: Mathematics: Master (alg) Selected topic in arithmetic geometry

Mod	dule na	me								
	Geo	metric \	/ariatio	onal Problems						
Mod no. 04-1 051		Credit	Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Seme		Freque Irregui	•
	guage (man and					son respons f. Dr. rer. na				ckmann
1	Course	es of the	e Modu	le	•					
	Course	e no.	Cours	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0511-vu Geometric Variational Problems 0 Lecture and 6 Exercise									
	With varying focus: Optimal surfaces in geometry, such as minimal surfaces (minima of surface area), Willmore surfaces (minima of bending energy), or problems under constraints, for instance surfaces of constant mean curvature; Representation of these surfaces as critical points of variational integrals as well as partial differential equations; Examples and existence statements, as well as properties of these surfaces, such as maximum principles.									
3	Studen - are al beyond - can d classes	ole to ex l a conc erive ex under o	aplain the rete exa istence consider	and uniqueness st	atem	ents as well				_
4	_			rticipation ential geometry						
5	Form of Examination Final Module Examination:									
	•	Modul Standa		ination (Technical	Exai	nination, ora	al / writ	ten Exa	aminati	on,
	test, ex	cept wh	en ther	al Examination): Use are only a small the form of an ora	num	ber of poten	tial parti	icipant	s. In th	is case, the

	is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature references provided in the lecture; examples include: Dierkes, Hildebrandt, Sauvigny: Minimal surfaces (Springer) Kenmotsu: Surfaces of constant mean curvature (AMS)
10	Comment recommended: Mathematics: Master (geo)

Mod	dule na	me									
	Opti	mizatio	n in M	achine Learning							
Mod no. 04-1 051	-	Credit	Points 5 CP	Workload 150 h	Self	-study 105 h	Duratio 1 Seme		Frequ Irregu	•	
		of Instru d Englisi			Person responsible for the Module Prof. Dr. rer. nat. Marc Pfetsch						
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name		Workload	(CP)	Forn Teac	n of hing	Contact Hours per Week	
	04-10-0)512-vu	Optimiz Learnin	ation in Machine		0		Lectui	re and ise	3	
2	Study Content classification (support vector machines), clustering, matrix completion, sparse regression, lasso, sparse inverse covariance selection, neural networks (deep learning), Markov random fields Possible societal implications will be addressed in the lecture										

3 Learning Outcomes

After attending this course, students will have an overview of machine learning. They know which mathematical optimization methods are applied in this context and have learned about their properties.

Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly

4 Requirements for Participation

recommended: Introduction to Optimization; useful: Discrete Optimization or Nonlinear Optimization

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Mitchell: Machine Learning. Mcgraw-Hill 1997

Murphy: Machine Learning: A Probabilistic Perspective, MIT Press 2012 Sra,Nowozin, Wright: Optimization for Machine Learning, MIT Press, 2012 Miroslav Kubat: An Introduction to Machine Learning. Springer, 2015.

10 Comment

recommended: Mathematics: Master (opt)

Мо	dule na	me								
	Onli	ne Opti	mizati	on						
Mo no. 04- 051	10-	Credit	Points 5 CP	Workload 150 h	Self-study Dura 105 h		Duratio 1 Seme		Freque Irregul	•
	nguage o					son respons . Dr. Yann D		the M	odule	
1	Course	es of the	e Modu	le	l					
	Course no. Course name Workload (CP) Form of Teaching Hours per Week									
	04-10-0513-vu Online Optimization 0 Lecture and Exercise 3									
3	Learni Studen - under - devel optimiz - are al	ng Outo ts estand a op an ac zation a ole to ex ole perfo	nd are a dvanced nd the o atend the orm sup	alancing and onling able to apply the nalled of understand competitive analysteir knowledge in the ervised research in	otion nding is of (s, methods as of the form online algora	and resu	lts trea	ated in t	
4	_			rticipation uction to Optimiza	tion					
5	Final M Fachpr test, ex	Standa üfung (' ccept whean be ta	Examina e Exam rd) Technic nen ther aken in		Jsual num l exa	ly the exam ber of poten m. The decis	is taken tial part: sion abo	in fori icipant	m of a w s. In thi form of	vritten is case, the the exam

prospective number of students taking the exam.

6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Borodin, El-Yaniv. Online Computation and Competitive Analysis. Cambridge University Press, 2005. Amos Fiat, Gerhard J. Woeginger. Online Algorithms: The State of the Art. Springer, 1998.
10	Comment recommended: Mathematics: Master (opt)

Mod	dule na	me								
	Func	tional	Analys i	s II						
Module no. C 04-10-		Credit Points 5 CP		Workload 150 h		- study 105 h	Duration 1 Semester		Frequency Irregular	
051										
	~ ~	of Instru				on respons				
Geri	man and	d Englis	h		Prof	Dr. rer. na	t. Reinha	ırd Faı	wig	
1	Courses of the Module									
	Course no. Cou		Cours	se name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)515-vu	Function	nal Analysis II		0		Lecture and Exercise		3
2	Study	Conten	t							
	Study Content Selected topics of linear functional analysis, e.g., spectral calculus of bounded and closed self-adjoint operators; Riesz' representation theorems of positive or continuous linear functionals on C^0; closed operators and definition by forms in Hilbert spaces; perturbation theory; semigroup theory; Bochner spaces; locally convex topological vector spaces									

Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an intermediate level of understanding of functional analysis - are able to extend their knowledge in this field **Requirements for Participation** recommended: Functional Analysis 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Passing the Fachprüfung 7 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** M.Sc. Mathematik, M.Sc. Mathematics Literature J. Weidmann: Linear Operators in Hilbert Spaces. Springer 1980 W. Rudin: Real and Complex Analysis. McGraw-Hill 1986 T. Kato: Perturbation Theory for Linear Operators. Springer 1995 K. Yosida: Functional Analysis. Springer 1995 K. Schmüdgen: Unbounded Self-adjoint Operators on Hilbert Space. Springer 2012 D. Werner: Funktionalanalysis. Springer 2000 Comment

Module Description

recommended: Mathematics: Master (ana)

Module name

	Redu	ıced Ba	sis Me	thods						
no.	4-10- 5 CP			Self	- study 105 h	Duratio 1 Semes		Freque Irregula	•	
	guage o man ano					on respons Dr. rer. nat			odule	
1	Course	es of the	e Modu	le		T		1		
	Course name		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)516-vu	Reduce	d Basis Methods		0		Lectur Exerci		3
2	 Study Content Reduced basis methods via Galerkin projection: construction, analysis and application proper orthogonal decomposition greedy algorithm estimation of the error in the solution and in functional outputs 							lication		
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of reduced basis methods - are able to extend their knowledge in this field - are able perform supervised research in this field									
4	_			rticipation rical Methods for F	artia	l Differentia	l Equatic	ons		
5		of Exam Iodule I								
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writt	en Exa	aminatio	on,
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	_	ements g the Fac		Award of Credit	Poin	ts				
7	Grading Final Module Examination:									

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature - Haasdonk: Reduced Basis Methods for Parametrized PDEs A Tutorial Introduction for Stationary and Instationary Problems, IANS, University of Stuttgart, Germany, 2014 - Quarteroni, Manzoni, Negri: Reduced Basis Methods for Partial Differential Equations: An Introduction, Springer, 2016 - Hesthaven, Rozza, Stamm: Certified Reduced Basis Methods for Parametrized Partial Differential Equations, Springer, 2016
10	Comment recommended: Mathematics: Master (num)

Mod	lule na	me								
	Mod	ular fo	rms of	several variables	5					
Mod no.	lule	Credit	Points	Workload	Self	-study	Duratio	n	Freque	encv
04-1 051	-		5 CP	150 h		•	1 Semes		Irregul	•
Language of Instruction German and English Person responsible for the Module Prof. Dr. rer. nat. Jan Hendrik Bruinier					r					
1		es of the		le						
	Course no.		Course	se name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)517-vu	Modula variable	r forms of several		0		Lectur Exerci		3
2	Introdu		the the	eory of modular fo r forms or Hilbert			riables f	or a cla	assical {	group,
3		ng Outo	comes							
	 develor variable 	Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of the theory of modular forms of several variables - are able to extend their knowledge in this field								

	- are able perform supervised research in this field
4	Requirements for Participation recommended: Algebra, recommended: Modular forms or Automorphic Forms
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature E. Freitag: Siegelsche Modulfunktionen; van der Geer: Hilbert modular surfaces; J.H. Bruinier, G. van der Geer, G. Harder, D. Zagier: The 1-2-3 of modular forms; H. Klingen: Introductory lectures on Siegel modular forms.
10	Comment recommended: Mathematics: Master (alg) Selected topic in automorphic forms

Module na	Module name									
Sele	ected Topics in	Analysis								
Module										
no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-10-	5 CP	150 h	105 h	1 Semester	Irregular					
0518										

Lan	guage of Instri	uction	Per	son responsible	for the Module			
	man and Englis			f. Dr. rer. nat. Rei				
1	Courses of the	e Module	1					
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week		
	04-10-0518-vu	Selected Topics in Analysis		0	Lecture and Exercise	3		
2	- chemotaxis - Besov spaces	topic, ide: equations Es						
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in analysis - are able to extend their knowledge in this field - are able perform supervised research in this field Requirements for Participation							
5	Form of Exam Final Module I		сапу	Functional Analy	7515			
		e Examination (Technical	l Exa	mination, oral / v	vritten Examinat	ion,		
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.							
6	Requirements Passing the Fa	on the Award of Credit	Poir	nts				
7	Grading Final Module I	Examination:						

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Master (ana)

Mod	lule na	me									
	Sele	cted To	pics in	Stochastics							
no. 04-1	Module no. Cred 04-10- 0519		Foints Workload 150 h		3		Duration 1 Semester		Frequency Irregular		
Language of Instruction German and English Courses of the Module					Person responsible for the Module Prof. Dr. rer. nat. Michael Kohler						
1	Course no. Course name				Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-10-0519-vu Selected Topics in Stochastics				cs				Lecture and 3 Exercise		
2	Study Content depending on topic, examples include: -random graphs and geometric models in probability -Malliavin calculus and stochastic analysis selected topics in Levy processes - selected chapters in mathematical statistics										
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in stochastics - are able to extend their knowledge in this field - are able perform supervised research in this field										
4	Requir	ements	for Pa	rticipation							

	recommended: depending on topic, at least Probability Theory
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment recommended: Mathematics: Master (sto)

Mod	Module name										
	Introduction to Algebra and Didactics of Algebra										
Module no. Credit Points				3		Duration		Frequency Every 2.			
04-1 052	10- 0/de		8 CP		240 h		165 h	1 Semes	ster	semester	
	guage man	of Instru	action				on respons . Dr. phil. na				
1	Cours	es of the	e Modul	le							
	Cours	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per

				Week
04-00-0006-vu	Introduction to Algebra	0	Lecture and Exercise	3
	Seminar for subject-specific didactics: Algebra in schools	0	Seminar	2

2 Study Content

Extension of number systems, treatment of equations and terms on secondary level, calculation skills, computer based learning, divisibility; typical student misconceptions; development of basic knowledge, learning strategies, principles and concepts of a spiral curriculum for secondary education

3 Learning Outcomes

Students attain pedagocical content knowledge in algebra and number theory and learn to apply this in various teaching and learning situations.

4 Requirements for Participation

Analysis, Linear Algebra, Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible)

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Standard)

6 Requirements on the Award of Credit Points

Passing the Fachprüfung; passing the Studienleistungen is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)

8 Usability of the Module

Mathematics: Teaching degrees

9 Literature

- S. Lang: Algebra, Addison-Wesley;
- N. Jacobson: Basic Algebra 1, Freeman
- S. Bosch: Algebra, Springer

different paper of Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.

Malle, G. (1993). Didaktische Probleme der elementaren Algebra. Vieweg,

Braunschweig/Wiesbaden. topical school books

10	Comment

Mod	dule na	me								
	Com	plex A	nalvsis	and Didactics of	Ana	lvsis				
no. 04-1	dule		-	Workload 240 h	Self-study 165 h		Duratio 1 Seme		Freque Every 2 semest	2.
	guage (of Instr	uction			son respons f. Dr. phil. na				
1	Course	es of the	e Modu	le						
	Course no. Course name					Workload	(CP)	Form Teac	-	Contact Hours per Week
04-00-0159-se Seminar for subject-specific 0 Seminar didactics: Analysis in schools						2				
	04-00-0225-vu Complex Analysis					0		Lectur Exerci		3
	Study Content Cauchy-Riemann differential equations, curve integrals, Cauchy's Integral Theorem and Formula; analyticity, Liouville's Theorem and Fundamental Theorem of Algebra; Winding Number; Laurent series and isolated singularities, Residue Theorem. Introduction to functions, analysis of functions, local change of rate and the definition of limit, integral definition by Riemann, misconceptions of students; upper level curriculum, lesson design, using of technology									
3	Studer		n pedago	ocical content kno earning situations		ge in analysi	s and le	arn to	apply th	nis in
4	Requirements for Participation Analysis, Linear Algebra, Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible)									
5		of Exam		-						
	Final N	Module 1	Examina	ition:						
	•	Modul	e Exam	ination (Study Exa	ımina	ation, Specia	l Form,	Passe	d / Not	Passed)
	Module Examination (Technical Examination, Special Form, Standard)									

Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistungen is a prerequisite for taking the Fachprüfung 7 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Weight: 100%, Standard) Usability of the Module Mathematics: Teaching degrees Literature Freitag: Funktionentheorie I, Springer. Remmert: Funktionentheorie I Conway: Functions of one complex variable, Springer Tietze, U.-P., Klika, M., Wolpers, H.-H.: Mathematikunterricht in der SII, Bd. 1, Fachdidaktische Grundfragen, Didaktik der Analysis. Vieweg 2000, Büchter, A., Henn, H.-W.: Elementare Analysis: Von der Anschauung zur Theorie. Spektrum 2010. Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Kratz, Henrik (2011). Wege zu einem kompetenzorientierten Mathematikunterricht – Ein Studien- und Praxisbuch für die Sekundarstufe. Kallmeyer – Klett, Seelze Gängige Schulbücher 10 Comment

Mod	Module name										
	Ordi	nary Di	fferent	ial Equations an	d Me	edia-Based	Teachin	g and	d Learni	ng	
Mod no.	lule	Credit	Points	Workload	Self	-study	Duratio	n	Freque:	•	
04-1 052	10- 2/de		8 CP	240 h		165 h	1 Semes	Semester		semester	
	Language of Instruction German					on respons . Dr. phil. na					
1	Course	es of the	Modul	le							
	Course no. Course name			Workload	(CP)	Form Teac		Contact Hours per			

					Week
	04-00-0054-vu	Ordinary Differential Equations	0	Lecture and Exercise	3
	04-00-0249-se	Seminar for subject-specific didactics: New media in mathematical lessons	0	Seminar	2
2	Study Conten	t			
	Separation of	variables, Theorems of Picard-l	Lindelöf and Peano, l	ocal and globa	l theory,

Separation of variables, Theorems of Picard-Lindelöf and Peano, local and global theory, linear systems of first and higher order, variation of constants formula, linearised stability, Lyapunov stability.

Technical feasibility, didactical concepts and application examples on spreadsheet analysis, dynamical geometry software, computer algebra systems, programming and didactical hardware.

3 Learning Outcomes

Students learn to use and apply various methods of media based teaching and learning (e.g. mathematical software, calculators, tablet PCs, interactive whiteboards and programming languages) in specific teaching and learning situations.

4 Requirements for Participation

Analysis and Linear Algebra and Foundations of Teaching and Learning of Mathematics, didactics of media

(participation without certification of prerequisites is possible)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

6 Requirements on the Award of Credit Points

Passing the Fachprüfung; passing the Studienleistungen is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematics: Teaching degrees

9 Literature

H. Amann: Gewöhnliche Differentialgleichungen, de Gruyter

W.Walther: gew. DGL, Springer

Different paper of Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.
Barzel, B., Hußmann, S., Leuders, T. (2005): Computer, Internet Co. im MathematikUnterricht. Cornelsen Verlag Scriptor.
paper of "mathematik lehren" and topical school books

10 Comment

Module Description

Mod	lule na	me								
	Elementary Number Theory and									
		Points 8 CP	Workload 240 h			1 Semester Ev		Freque Every 4 semeste	ł.	
German Prof. D						son respons . Dr. phil. na				
1	Course	es of the	e Modul	le		1		1		
	Course	e no.	Course	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-00-0039-se Seminar for subject-specif didactics: Algebra in school			0		Semin	ar	2		
	04-10-0389-vu Elementary Number Theory (Lehramt)			•	0		Lectur Exerci	-	3	

2 Study Content

Primzahlen, Primfaktorzerlegung, Kongruenzen, Fermats kleiner Satz, RSA-Kryptosystem, Legendre-Symbol, quadratische Reziprozität.

Ausblick in Gaußsche ganze Zahlen, den Dirichletschen Primzahlsatz oder das Fermatsche Problem.

Zahlbereichserweiterungen und Behandlung von Gleichungen und Termen in den beiden Sekundarstufen, Rechnenkönnen, Technologieeinsatz, Teilbarkeitsuntersuchungen; typische Schülerfehler, Aufbau von Grundvorstellungen, Möglichkeiten der Nutzung von Strategien, Prinzipien und Modellen für die Entwicklung eines Spiralcurriculums bis zur Oberstufe.

3 Learning Outcomes

Einführung in die elementare Zahlentheorie und Behandlung einiger klassischer Probleme

Die Studierenden...

- ...erlangen fachliche Sicherheit in schulrelevanten Aspekten der Algebra und Zahlentheorie.
- ...beherrschen Darstellungen und Konzepte, um Themengebiete der Algebra in der Schule

zu veranschaulichen, sprachsensibel und binnendifferenzierend zu gestalten.können anhand der in den Übungen praktizierten zahlreichen Beispiele Kriterien für intelligentes Üben und Begabtenförderung erläutern und entwickeln ihre diagnostische Kompetenz **Requirements for Participation** Linear Algebra, Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible) 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, Special Form, Standard) Module Examination (Study Examination, Special Form, Passed / Not Passed) **Requirements on the Award of Credit Points** Passing the Fachprüfung; passing the Studienleistungen is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, Special Form, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) **Usability of the Module** Mathematics: Teaching degrees Literature A. Beck, M.N. Bleicher, D.W. Crowe: Excursions into Mathematics. Worth Publishers, Inc.1969. B.M. Steward: Theory of Numbers 2nd ed. The Macmillian Company. New York 1964 Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Malle, G. (1993). Didaktische Probleme der elementaren Algebra. Vieweg, Braunschweig/Wiesbaden. Gängige Schulbücher 10 Comment

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	ш	.,	u	ч			а		•

N /	lule	.,	uutioii	s, and Online Tra		9		iaski	, 	
no. 04-1		Credit	Points 8 CP	Workload 240 h		Self-study Durati 165 h 1 Seme			Fueru 4	
	guage o	of Instru	ıction			son respons				
1	l	es of the	- Modu	 le	1101	D1. piiii. iii	it. Italja	Tu uge.		
-	Course			e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0	109-se		r for subject-specific s: Online task traini		0 Semi			ar	2
04-00-0144-vu Logic and Foundations (for Teaching Degrees) Lecture and Exercise							3			
3	optimization, graph theory, Bezier curves, Benford law, cryptography, stochastic, combinatorial analysis, etc- Learning Outcomes									
	Die Stu - Fähig Mather Theme - Vorste ausgew - digita Lernpo - Hand Mather Studen - solve docum - suppo - emple	idierence keiten in natikau nfeldern ellunger vählten te Feedl tential v lungswi matik. ts learn mathen ent thei ort gifted	len erwent Löser fgaben in it is it	a und digitalen Do aus verschiedenen estaltung von Arbe i; hniken und Bewus dener Lösungsweg r Theorie des Arbe asks in various top ons digitally; ats; l tasks adequately	itsge itsge sthei ge eitens	ilrelevanten meinschafte t über Probl mit Aufgab	n mit int emlöse-s en beim	eressie trateg Lehrer	erten So ien und 1 und L	das ernen von
4	Requirements for Participation basic mathematical knowledge from the first semester, Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible)									
5	Form of Examination Final Module Examination:									

Module Examination (Study Examination, Special Form, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Standard) **Requirements on the Award of Credit Points** Passing the Fachprüfung; passing the Studienleistungen is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Weight: 100%, Standard) **Usability of the Module** Mathematics: Teaching degrees Literature (examples include) Forster, T.: Logic, Induction and Sets. CUP, 234pp., 2003 Kay, R.: The Mathematics of Logic. CUP, 204pp., 2007 Schindler, R.: Logische Grundlagen der Mathematik. Springer, 203pp., 2009 MOODLE-Kurs online mit Skript Barzel, B., Hußmann, S., Leuders, T. (2005): Computer, Internet Co. im Mathematik-Unterricht. Cornelsen Verlag Scriptor. 10 Comment

Module Description

Mod	Module name										
	Selected Topics in Lie Algebra Theory										
		Credit Points				Self-study 105 h		Duration		Frequency Every 2.	
04-10- 5 CP 0526/de			150 h	1 Semes	ter			semeste	r		
Language of Instruction Person responsible for the Module											
Geri	man an	d Englisl	h			Prof.	Dr. rer. nat	. Nils Scl	heitha	uer	
1	Course	es of the	e Modul	le							
	Course no. Course name						Workload	(CP)	Form Teac		Contact Hours per Week

Das Aufgabenpraktikum ist eine online-Veranstaltung mit tutorieller Begleitung.

	04-10-0526-7/11	Selected Topics in Lie Algebra	0	Lecture and	3					
	07-10-0320-vu	Theory	O .	Exercise	3					
2	Study Content depending on topics, examples include: - Representation theory of semisimple groups - Kac-Moody algebras - Introduction to the theory of vertex algebras									
3	- develop an ac	nd are able to apply the notion lyanced level of understanding tend their knowledge in this form supervised research in this	g of a topic in vertex ield							
4	Requirements for Participation (participation without certification of prerequisites is possible)									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
6	Passing the Fac	on the Award of Credit Point chprüfung (normally the exam de exam can be held as a writte	is held orally; in cas	se of a large n	umber of					
7		e Examination: e Examination (Technical Examination)	mination, oral / writ	ten Examinati	on,					
8	Usability of th	e Module Mathematics: Master (alg)								
9	Literature Serre: Complex semisimple Lie algebras Humphreys: Introduction to Lie algebras and representation theory Bourbaki: Lie groups and Lie algebras Kac: Infinite dimensional Lie algebras Carter: Lie algebras of finite and affine type Kac: Vertex algebras for beginners Frenkel, Ben-Zvi: Vertex algebras and algebraic curves									
10	Comment									

Mod	dule na	me								
	Ordi	nary Di	fferent	ial Equations (fo	r M	echanics)				
Mod no. 04-1 052		Credit	Points 5 CP	Workload 150 h	Self	Self-study 105 h		o n ster	Frequency Every 2. semester	
	guage o man	of Instru	ıction			son respons f. Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no. Course name				Workload (CP) Form of Teaching			-	Contact Hours per Week	
	04-00-0	04-00-0054-vu Ordinary Differential Equations 0 Lecture and Exercise 3								
2	Separation of variables, Theorems of Picard-Lindelöf and Peano, local and global theory, linear systems of first and higher order, variation of constants formula, linearised stability, Lyapunov stability.									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of the theory of ordinary differential equations - are able to recognise the treated concepts in various fields of mathematics									
4	Analys	is and L	inear Al	rticipation gebra certification of pro	ereqı	uisites is pos	sible)			
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) • Module Examination (Study Examination, Special Form, Passed / Not Passed)									
6	Passing particij passing	g the Fac pants the g the Stu	chprüfu e exam ıdienlei	Award of Crediting (normally the ecan be held as a wastung (typically so the Fachprüfung	exam vritte	is held orall n test);				

7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
	Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	B.Sc. Applied mechanics
9	Literature H. Amann: Gewöhnliche Differentialgleichungen, de Gruyter W.Walther: gew. DGL, Springer
10	Comment

Module name											
Didactics of Algebra											
Module no. Cred 04-10- 0530/de		Credit	Points 3 CP	Points Workload 90 h		Self-study 60 h		Duration 1 Semester		Frequency Every 2. semester	
Language of InstructionPerson responsible for the ModuleGermanProf. Dr. päd. Regina Bruder											
1	Course	es of the	e Modu	le							
	Course no. Course name 04-00-0039-se Seminar for subject-specifi didactics: Algebra in school			Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
							Seminar		2		
2	Study Content Zahlbereichserweiterungen und Behandlung von Gleichungen und Termen in den beiden Sekundarstufen, Rechnenkönnen, Technologieeinsatz, Teilbarkeitsuntersuchungen; typische Schülerfehler, Aufbau von Grundvorstellungen, Möglichkeiten der Nutzung von Strategien, Prinzipien und Modellen für die Entwicklung eines Spiralcurriculums bis zur Sekundarstufe II.										
3	Learning Outcomes Die Studierenden										

...erlangen fachliche Sicherheit in schulrelevanten Aspekten der Algebra und Zahlentheorie. ...beherrschen Darstellungen und Konzepte, um Themengebiete der Algebra in der Schule zu veranschaulichen, sprachsensibel und binnendifferenzierend zu gestalten.können anhand der in den Übungen praktizierten zahlreichen Beispiele Kriterien für intelligentes Üben und Begabtenförderung erläutern und entwickeln ihre diagnostische Kompetenz **Requirements for Participation** Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible) Form of Examination Final Module Examination: Module Examination (Technical Examination, Special Form, Standard) Module Examination (Study Examination, Special Form, Passed / Not Passed) **Requirements on the Award of Credit Points** Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, Special Form, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) **Usability of the Module** Mathematics: Teaching degrees Literature different paper of Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Malle, G. (1993). Didaktische Probleme der elementaren Algebra. Vieweg, Braunschweig/Wiesbaden. topical school books 10 Comment

Module Description

Module name

	Dida	ctics of	Analy	sis								
no. 04-1	lule	Credit Points 3 CP		Workload	90 h	Self	f- study 60 h	Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German					Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger							
1	Courses of the Module											
	Course no.		Cours	ourse name			Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0	159-se		r for subject-spe s: Analysis in so			0		Semin	ıar	2	
2	Study Content Introduction to functions, analysis of functions, local change of rate and the definition of limit, integral definition by Riemann, misconceptions of students; upper level curriculum, lesson design, using of technology											
3	Learning Outcomes Die Studierendenerlangen fachliche Sicherheit in besonders schulrelevanten Aspekten der Analysis und können verschiedene Zugänge und Schwerpunktsetzungen gegeneinander abwägenbeherrschen Darstellungen und Konzepte, um Themengebiete der Analysis in der Schule zu veranschaulichen - auch mit Technologieeinsatzpraktizieren in den Übungen zahlreiche Beispiele für intelligentes Üben, Diagnose und Förderung.									vägen. 1 der		
4	Requirements for Participation Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible)											
5	Form of Examination Final Module Examination:											
	•	Modul	e Exam	ination (Techr	nical	Exa	mination, Sp	ecial Fo	orm, St	andard)	
	•	Modul	e Exam	ination (Study	Exa	min	ation, Specia	ıl Form,	Passe	d / Not	Passed)	
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung											
7	Grading Final Module Examination: • Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)											

	Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	Mathematics: Teaching degrees
9	Literature Tietze, UP., Klika,M., Wolpers, HH.: Mathematikunterricht in der SII, Bd. 1, Fachdidaktische Grundfragen, Didaktik der Analysis. Vieweg 2000, Büchter, A., Henn, HW.: Elementare Analysis: Von der Anschauung zur Theorie. Spektrum 2010. different paper of Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. topical school books
10	Comment

Module name											
Didactics of Stochastics											
Module no. Credit Points Workload					Self-study Duration		Duratio	on Freque		ncv	
04-10- 0532/de		3 CP			90 h			1 Semester		Irregular	
Language of Instruction German Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger											
1	Course	es of the	e Modu	le							
	Course no.		Course name				Workload (CP)			n of hing	Contact Hours per Week
			Seminar for subject-specific didactics: Stochastics in school				0		Seminar		2
2	Study Content History of Probability; History of Statistics; Didactical Analysis of Fundamental Concepts of Probability; Representations of Data; Paradoxes of Probability.										
3	Learning Outcomes Students learn to explain central question of stochastics in their historical context, analyse the specific challenges of teaching and learning stochastics in schools, reflect various approaches towards problems in stochastics.										
4	Requirements for Participation										

Foundations of Teaching and Learning of Mathematics, Introduction to Stochastics (participation without certification of prerequisites is possible)

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

Mathematics: Teaching degrees

9 Literature

Victor Katz: A History of Mathematics. Harper Collins, 1993.

- E. Kaplan, M. Kaplan: Eins zu Tausend. Die Geschichte der Wahrscheinlichkeitsrechnung. Campus Verlag, 2007.
- C. C. Gillispie: Dictionary of Scientific Biography. Charles Scribner.s Sons, 1970 1991.
- A. Desrosières: Die Politik der großen Zahlen. Eine Geschichte der statistischen Denkweise. Springer, 2005.
- R. Biehler, J. Engel: Stochastik: Leitidee Daten und Zufall. In R. Bruder, L. Hefendehl-Hebeker, B. Schmidt-Thieme, G.-G. Weigand (Hrsg.): Handbuch der Mathematikdidaktik, Springer Sprektrum 2015, S. 221 -251.
- U.-P. Tietze, M. Klika, H. Wolpers: Mathematikunterricht in der Sekundarstufe II. Band 3: Didaktik der Stochastik. Vieweg 2002.
- H.-H. Dubben, H.-P. Beck-Bornholdt: Mit an Wahrscheinlichkeit grenzender Sicherheit: Logisches Denken und Zufall. Rowohlt, 2007.

10 Comment

Module name											
Didactics of Geometry											
Mod no. 04-1 0533	lule	Credit Points 3 CP			Self-study 60		Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German			Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger								
1	Course	s of the	e Modu	le							
	Course no. Course		e name	Workloa	Workload (CP)		n of ching	Contact Hours per Week			
	04-10-0	533-se	Didactio	es of Geometry	0		Semir	nar	2		
2	Study Content Mathematical and non-mathematical aspects of geometry; typical geometrical activities; mathematical and natural language in the context of geometry; practical aspects of teaching and learning geometry.								-		
3	Learning Outcomes Students attain pedagocical content knowledge in geometry and learn to apply this in various teaching and learning situations.								this in		
4	Requirements for Participation Foundations of Teaching and Learning of Mathematics (participation without certification of prerequisites is possible)										
5	Form o	of Exam	ination	l							
	Final M	Iodule I	Examina	ition:							
	•	Modul	e Exam	ination (Technical	Examination,	Special Fo	orm, S	tandard))		
	Module Examination (Study Examination, Special Form, Passed / Not Passed)								Passed)		
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung										
7	Grading Final Module Examination:										
	Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)										

	Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module
	Mathematics: Teaching degrees
9	Literature
	Hattermann/Kadunz/Rezat/Sträßer: Leitidee Raum und Form. In Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Praxis der Mathematik in der Schule (Heft 45): Ausgesprochen Mathe – Sprachen fördern ml 196: Problemlösen lernen in der Geometrie, Seelze Friedrich (2016) Leisen, Josef (2010): Handbuch Sprachförderung im Fach. Varus Verlag Wessel, L.(2015). Fach- und sprachintegrierte Förderung durch Darstellungsvernetzung und Scaffolding. Dortmunder Beiträge zur Entwicklung und Erforschung des Mathematikunterrichts Band 19 (Hrsg. Hußmann; Nührenbörger; Prediger; Selter). SpringerSpektrum
10	Comment

Mod	dule na	me								
	Fach	didakti	isches S	eminar: Medie	n in c	ler Schule				
	lule	6 11.	.	11 1	. 1	o . 1	_		_	
no.		Credit		Workload		f-study	Duratio		Freque	•
04-1 053	10- 4/de		3 CP	90 1	1	60 h	1 Semes	ster	Every s	emester
Lan	guage o	of Instru	uction		Per	son respons	ible for	the M	odule	
Geri	man				Pro	f. Dr. phil. na	at. Katja	Krüge	r	
1	Course	es of the	e Modu	le						
	Course no.		Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)249-se	didactic	r for subject-specifi s: New media in natical lessons	c	0		Semin	ar	2
2	Study Content Technical feasibility, didactical concepts and application examples on spreadsheet analysis, dynamical geometry software, computer algebra systems, programming and didactical hardware.									
3	Learni	ng Out	comes							
		ıdierend								

...erlangen Grundkenntnisse in den gängigsten Mathematikprogrammkategorien, im Umgang mit Taschenrechnern, Tablets, interaktiven Whiteboards und im Programmieren. ...können Medienanwendungen mit unterschiedlichen didaktischen Konzepten begründen und entwickeln. **Requirements for Participation** Foundations of Teaching and Learning of Mathematics, didactics of media (participation without certification of prerequisites is possible) 5 Form of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Standard) **Requirements on the Award of Credit Points** Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Weight: 100%, Standard) **Usability of the Module** Mathematics: Teaching degrees Literature Paper of Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Barzel, B., Hußmann, S., Leuders, T. (2005): Computer, Internet Co. im Mathematik-Unterricht. Cornelsen Verlag Scriptor. Papers of "mathematik lehren" and text books for schools 10 Comment

Module na	Module name												
Fachdidaktisches Seminar: Aufgabenpraktikum online													
Module	Credit Points	Workload	Self-study	Duration	Frequency								
no.	3 CP	90 h	60 h	1 Semester	Every semester								

04-1	10									
	5/de									
	guage of Instruction man and English		son respons f. Dr. phil. na			dule				
1	Courses of the Module		_							
	Course no. Course name		Workload	(CP)	Form of Teach		Contact Hours per Week			
	04-00-0109-se Seminar for subject-speci didactics: Online task tra		0		Semina	r	2			
2	Study Content Selection of sub-modules such as getting to know puzzles, spirals, business mathematics, optimization, graph theory, Bezier curves, Benford law, cryptography, stochastic, combinatorial analysis, etc-									
3	Learning Outcomes Die Studierenden erwerben - Fähigkeiten im Lösen und digitalen Dokumentieren von Lösungswegen von Mathematikaufgaben aus verschiedenen schulrelevanten Themenfeldern; - Vorstellungen zur Gestaltung von Arbeitsgemeinschaften mit interessierten Schülern zu ausgewählten Themen; - digitale Feedbacktechniken und Bewusstheit über Problemlösestrategien und das Lernpotential verschiedener Lösungswege -Handlungswissen zur Theorie des Arbeitens mit Aufgaben beim Lehren und Lernen von Mathematik.									
4	Requirements for Participation Foundations of Teaching and Learning (participation without certification of			sible)						
5	Form of Examination Final Module Examination: • Module Examination (Study Examination (Technic		• •							
6	Requirements on the Award of Cred Passing the Fachprüfung; passing the Fachprüfung			prereq	uisite for	takin	ng the			
7	Grading Final Module Examination: • Module Examination (Study Examination (Study Examination)	Examin	ation, Specia	ıl Form,	Weight:	0%, I	Passed /			

	Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
8	Usability of the Module
	Mathematics: Teaching degrees
9	Literature
	MOODLE-Kurs online
10	Comment
	Das Aufgabenpraktikum ist eine online-Veranstaltung mit tutorieller Begleitung.

Mod	lule na	me								
	Dive	rse Lea	rning E	nvironments						
Mod no. 04-1 0540		Credit Points 6 CP		Workload 180 h	Self-study 120 h		Duration 1 Semester		Frequency Every 4. semester	
	Language of Instruction German					son respons . Dr. phil. na				
1	Course	es of the	e Modu	le						
	Course no. Course name				Workload	(CP)	Form Teac		Contact Hours per Week	
	04-10-0)540-pj	Diverse	Learning Environme	ents	0		Projec	t	4
2										
3	Learning Outcomes Students attain - knowledge and skills in long-term development of competencies - experience in analysing and evaluating of learning materials.									
4	4 Requirements for Participation Foundations of Teaching and Learning of Mathematics, Practise phase III (participation without certification of prerequisites is possible)									
5	Form o	of Exam	ination	1						

	Final Module Examination:
	Module Examination (Technical Examination, Special Form, Standard)
	Module Examination (Study Examination, Special Form, Passed / Not Passed)
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung
7	Grading Final Module Examination:
	 Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
	 Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
8	Usability of the Module Mathematics: Teaching degrees
9	Literature Artikel aus "mathematik lehren" und gängige Schulbücher, Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.
10	Comment

Mod	Iodule name										
	Problem Solving										
Mod no. 04-1 054		Credit	Points 6 CP	Workload	180 h	l	study 120 h	Duratio 1 Semes		Freque Every 4 semeste	.
	Language of Instruction German					Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger					
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0	0043-pj	Problem	Solving			0		Projec	t	4

2 Study Content

Various terms and concepts of problem solving; overview over research results; strategies and methods of problem solving; reflection on the difficulty of problems;

3 Learning Outcomes

Students attain

- knowledge and skills in long-term development of competencies
- experience in analysing and evaluating of learning materials.

4 Requirements for Participation

Foundations of Teaching and Learning of Mathematics, Practise phase III (participation without certification of prerequisites is possible)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

6 Requirements on the Award of Credit Points

Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematics: Teaching degrees

9 Literature

Bruder,R., Collet,C.: Problemlösenlernen im Mathematikunterricht. Cornelsen Scriptor (2009)

Büchter, A., Leuders, T.: Mathematikaufgaben selbst entwickeln. Cornelsen (2005) Polya, G.: Schule des Denkens. Vom Lösen mathematischer Probleme. (1949) Zeitschrift "mathematik lehren": verschiedene Beiträge,

Aufgaben aus Mathematikwettbewerben

10 Comment

Mod	lule na	me								
	Appl	ication	-Orient	ed Teaching and	d Lea	rning of M	athema	tics		
Mod no. 04-1 0542	lule	Credit Points 6 CP			Self-			on	Frequency Every 4. semester	
Lan ; Geri		of Instru	ıction			on respons Dr. phil. na				
1	Course	s of the	e Modu	le						
	Course no. Course name		e name		Workload (CP)		Form Teac		Contact Hours per Week	
	04-00-0)113-рј	Applica	-specific project: tion-oriented natical lessons	ı	0		Projec	t	4
2	Study Content Various terms and concepts of application-oriented teaching and learning of mathematics; Fermi-problems, descriptive and normative modeling; strategies and methods of modeling; reflection on the difficulty of modeling problems;									
3	Studen - know	_	n nd skills	in long-term deveing and evaluating	_	_		:		
4	Founda	ations o	f Teachi	rticipation ng and Learning o certification of pro				hase I	II	
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Special Form, Standard) • Module Examination (Study Examination, Special Form, Passed / Not Passed)									
6	-	the Fa		Award of Credit ng; passing the Stu			prerequ	isite fo	or taking	g the
7	Gradin Final M	•	Examina	ition:						

Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
 Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
 Usability of the Module Mathematics: Teaching degrees
 Literature ISTRON-Materialien Bd. 1 - 14 Büchter, A., Leuders, T.: Mathematikaufgaben selbst entwickeln. Cornelsen (2005) Zeitschrift "mathematik lehren": ausgewählte Beiträge Herget/Scholz: Die etwas andere Aufgabe - aus der Zeitung, Kallmeyersche Verlagsbuchhandlung, Seelze 1998 Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.
 Comment

Mod	lule na	me								
	Asse	ssment	t of Ma	thematical Com	pete	ncies				
no. 04-1	Module no. Credit Points 04-10- 6 CP 0543/de		Workload 180 h	Self-study 120 h		Duration 1 Semester		Frequency Every 4. semester		
Lan Geri		of Instru	action			son respons f. Dr. phil. na				
1	Courses of the Module									
	Course no.		Course	irse name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)038-pj	Assessm Compet	ent of Mathematic encies	al	0		Projec	t	4
2	Study Content Reflection on diagnostic abilities; assements and their relation to everyday teaching; development of assessments; diagnosis of typical misconceptions									
3	Studen	ng Outo its attair ledge ai	ı	in long-term dev	elopn	nent of comp	etencies			

	- experience in analysing and evaluating of learning materials.
4	Requirements for Participation Foundations of Teaching and Learning of Mathematics, Practise phase III (participation without certification of prerequisites is possible)
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) • Module Examination (Technical Examination, Special Form, Standard)
6	Requirements on the Award of Credit Points Passing the Fachprüfung; passing the Studienleistung is a prerequisite for taking the Fachprüfung
7	 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
8	Usability of the Module Mathematics: Teaching degrees
9	Literature Baumert et al. PISA 2000, PISA 2003 Relevante Beiträge in Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Fritz, A., Schmidt, S. (Hrsg.). Fördernder Mathematikunterricht in der SEK I. Beltz 2009 Mathematik Lehren 150/2008. Diagnose – Schritte zum Fördern Mathematik Lehren 170/2012. Beurteilen und Bewerten Praxis der Mathematik Heft 15/49 (2007). Diagnose – Schülerleistungen verstehen Praxis der Mathematik Heft 56/56 (2014). Schwierigkeiten in Mathematik begegnen Praxis der Mathematik Heft 63/57 (2015). Klassenarbeiten – prüfen und gestalten
10	Comment Verantwortlich: Frau Krüger (did)

Module name											
Sele	Selected Topics in Numerics										
Module	Credit Points	Workload	Self-study	Duration	Frequency						

no. 04-1 0550	.0- 0/de		5 CP	150 h		105 h	1 Semes	ester Every semes			
Lan ; Geri	0	of Instru	uction		Person responsible for the Module Prof. Dr. rer. nat. Jens Lang						
1	Course	es of the	e Modul	e	•						
	Course no. Course name		e name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-10-0)550-vu	Selected	Topics in Numeric		0		Lectur Exerci		3	
2	depend		topic, ex	camples include: es of singularly per	turbe	ed problems					
3	Studen - under - devel - are al	estand a op an ac ole to ex	nd are a dvanced atend the	ble to apply the nelevel of understareir knowledge in the	nding his fi	of a topic in				the course	
4	-			ticipation certification of pro	erequ	isites is pos	sible)				
5		Iodule I			Exan	nination, or	al / writt	en Ex	aminati	on,	
6	Passing	g the Fa	chprüfu	Award of Crediting (normally the ecan be held as a w	xam	is held orall	ly; in cas	e of a	large n	umber of	
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)										
8		•	ne Modu : Mather	i le natics: Master (nu	ım)						
9	Literat depend	ure ling on	topic								

10	Comment

IVIO	dule na	me								
no. 04-	dule			Workload 150 h	Self-	- study 105 h	Duratio 1 Seme		Freque Irregul	•
	iguage o	of Instru	action			on respons . Dr. rer. nat				
1	Course	es of the	e Modul	le				T		
	Course no. Course name					Workload	(CP)	Forn Teac	n of hing	Contact Hours per Week
	04-10-0)551-vu	Introdu	ction to Lie Algebras	3	0		Lectui Exerci	re and ise	3
	Semisi	mnla I id	1 1					_		
3	Lie alg Learni The stu	ebras, b	asic prir	as, Cartan subalge nciples of the representations of the representations of the representations of the structure theory of the representations of the structure theory.	esenta	ation theory	of semi	simple	Lie algo	ebras
3	Lie alg Learni The stu of the	ebras, b ing Outo udents k represer	comes now the	e structure theory cheory.	esenta	ation theory	of semi	simple	Lie algo	ebras

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Serre: Complex semisimple Lie algebras, Springer Humphreys: Introduction to Lie algebras and representation theory, Springer Bourbaki: Lie groups and Lie algebras, Springer Carter: Lie algebras of finite and affine type, Cambridge University Press
10	Comment recommended: Mathematics: Bachelor year 3 (alg)

Mod	dule na	me								
	Alge	braic G	roups							
		Points 9 CP	Workload 270 h	Self-study Dura 180 h		Duration 1 Semes		-	F requency Trregular	
	Language of Instruction German and English					on respons . Dr. rer. na				edhorn
1	Course	es of the	e Modu	le						
	Course no. Course		e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)552-vu	Algebra	ic Groups		0		Lecture and Exercise		6
2	Study Content Algebraic groups, homomorphisms, linear and reductive groups or abelian varieties									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of the theory of algebraic groups									

	- are able to extend their knowledge in this field
4	Requirements for Participation recommended: Algebraic Geometry
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature A. Borel: Linear algebraic groups, Springer T. Springer: Linear algebraic groups, Birkhäuser D. Mumford: Abelian varieties, Tata Institute of Fundamental Research
10	Comment recommended: Mathematics: Master (alg)

Module name									
Alge	braic Curves								
Module no.	Credit Points	Workload	Self-study	Duration	Frequency				
04-10- 0553	5 CP	150 h	105 h	1 Semester	Irregular				
Language	Language of Instruction Person responsible for the Module								

Ger	man and Englis	h	Prof. Dr. rer. nat. Nils Scheithauer							
1	Courses of the	e Module								
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-10-0553-vu	Algebraic Curves		0	Lecture and Exercise	3				
2	Study Content Affine varieties, affine plane curves, projective varieties, projective plane curves, Bezout's Theorem, morphisms, rational maps, the Riemann-Roch Theorem									
3	main theorems	comes are familiar with the basic as, as e.g. Bezout's theorem geometrical questions.		-	-					
4	Requirements recommended	s for Participation : Algebra								
5	Standa Fachprüfung (' test, except whexam can be taken and co	Examination: le Examination (Technical	Jsual numl l exai irst tv	ly the exam is taken ber of potential part m. The decision abo vo weeks of the lect	n in form of a w ticipants. In thi out the form of	vritten s case, the the exam				
6	Requirements Passing the Fac	s on the Award of Credit chprüfung	Poin	ts						
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of the B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M.	.Sc. M	lathematics						
9	Hartshorne: Al	aic curves, http://www.m lgebraic geometry, Springo ction to plane algebraic cu	er		ılton/CurveBoo	ok.pdf				

10	Comment recommended: Mathematics: Master (alg)

		ductio	n to Sc	entific Programı	ning	1	T		ı		
Module no. 04-10-0554/de		Credit Points 3 CP				•		Duration 1 Semester		Frequency Every 2. semester	
	i guage (man	of Instru	action			son respons rer. nat. And					
1	Course	es of the	e Modu	le	l						
	Course no.		Cours	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week	
	04-10-0)554-vu	Introduction to Scientific Programming 1			0		Lecture and Exercise		4	
	- Basic express function - Notion	principl sions, st ons).	les of C andard mplexit	compiler on a Linu (data types includ functions, boolean y of algorithms (m	ing n	nemory man rations, cont	rol struc	-	-		
	Learning Outcomes Students show basic knowledge of programming techniques in the programming language C. They are able to design, implement and test basic mathematical algorithms in a correct, clearly laid out, well-structured and well-documented way.										
3	_	_	early lai	d out, well-structu	red a				_	0	
3	in a co	rrect, cl		d out, well-structuricticipation	ired a				_	0	

	Successful completion of mathematical and coding assignments. The number of assignments and the relevant marking scheme will be announced by the instructor during the first lecture.
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik, B.Sc. Angewandte Mechanik, B.Sc. CE
9	Literature Elias Fischer, C-HowTo: Programmieren lernen mit der Programmiersprache C, Books on Demand, ISBN 9783839181041, 2012. Online unter: http://www.c-howto.de/tutorial.html
10	Comment recommended: Mathematics: Bachelor year 1

Mod	lule naı	me								
	Intro	ductio	n to Sci	entific Programı	ming	2				
Module no. Cre 04-10- 0555/de		Credit	Points 3 CP	Workload 90 h	•		Duratio 1 Semes		Frequency Every 2. semester	
	Language of Instruction					son respons		the M	odule	
Geri	man				Dr. 1	rer. nat. Alf	Gerisch			
1	Course	s of the	e Modul	le						
			Course	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0555-vu Introduction to Scientific Programming 2				0 Lectur Exerci				4	
2	Study	Conten	t							
	- Introd	luction	of the S	ect oriented progr tandard Template eues, stacks).		-				

- Awareness for problems associated with using floating point arithmetic.
- Use and implementation of libraries (techniques and examples).
- Introduction to the programming with Matlab (control structures, functions, vector operations, graphics, mex interface).

3 Learning Outcomes

Building on EP1, students have a good command of basic techniques of object oriented programming in the programming language C++. They are able to design, implement and test basic mathematical algorithms in a correct, clearly laid out, well-structured and well-documented way. Students are able to include existing code libraries into their program. Building on their acquired programming skills, students can confidently use the Matlab programming environment to implement simple mathematical algorithms.

4 Requirements for Participation

recommended: Introduction to Scientific Programming 1

5 Form of Examination

Final Module Examination:

Module Examination (Study Examination, Special Form, Passed / Not Passed)

Successful completion of mathematical and coding assignments. The number of assignments and the

relevant marking scheme will be announced by the instructor during the first lecture.

6 Requirements on the Award of Credit Points

Passing the Studienleistung

7 Grading

Final Module Examination:

 Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)

8 Usability of the Module

B.Sc. Mathematik, B.Sc. Angewandte Mechanik, B.Sc. CE

9 Literature

- J. Pitt-Francis J Whiteley, Guide to Scientific Computing in C++, Springer-Verlag London, ISBN 9781447127352, 2012.
- B. Stroustrup, The C++ Programming Language, 4th Edition, Addison-Wesley, ISBN 9780321563842, 2013.
- The C++ Ressources Network. Online: http://www.cplusplus.com/
- Matlab Online Documentation, The Mathworks. Online:

http://de.mathworks.com/help/matlab/index.html

10 Comment

recommended: Mathematics: Bachelor year 1

Mod	lule na	me								
	Distr	ibution	ıs							
no. 04-1	Module no. Credit Points Wo 04-10- 5 CP 0556/de		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular		
	Language of Instruction German					son respons . Dr. rer. nat				
1	Course	es of the	Modu	le						
	Course no. Course		e name	Workload ((CP)	Form of Teaching		Contact Hours per Week	
	04-10-0)556-vu	Distribu	tions		0		Lectur Exerci		3
2	Study Content Spaces D and D' and S and S'; Fourier transform, fundamental solutions, Sobolev spaces									
4	Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of the theory of distributions - are able to recognise the treated concepts in various fields of mathematics. Requirements for Participation									
	recomr	nended:	Function	onal Analysis						
5		of Exam Iodule E								
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writt	ten Exa	aminati	on,
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	_	ements g the Fac		Award of Credit	Poin	ts				
7	Gradin	ıg								

	Final Module Examination:
	 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999. W. Walter, Distributionen J. Duistermaat, Distributions, Springer, 2010. M. Renardy, R.C. Rogers: An Introduction to Partial Differential Equations, Second Edition, 2004, 1993, Springer.
10	Comment recommended: Mathematics: Bachelor year 3 (ana)

Mod	lule na									
	Distr	ributior	ıs		T				Ţ	
Module no. 04-10-		Credit	Points Workload 5 CP 150 h		Self-study 105 h		Duration 1 Semester		Frequency Irregular	
Construction Language of Instruction English					on respons					
1	Courses of the Module									
	Course no. Cou		Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)556-vu	Distribu	tions		0		Lecture and Exercise		3
2	Study Content Spaces D and D' and S and S'; Fourier transform, fundamental solutions, Sobolev spaces									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of the theory of distributions - are able to recognise the treated concepts in various fields of mathematics.									

4 Requirements for Participation

recommended: Analysis, Ordinary Differetial Equations, Complex Analysis, Integration Theory

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc. Mathematics

9 Literature

- W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999.
- W. Walter, Distributionen
- J. Duistermaat, Distributions, Springer, 2010.
- M. Renardy, R.C. Rogers: An Introduction to Partial Differential Equations, Second Edition, 2004, 1993, Springer.

10 Comment

recommended: Mathematics: Bachelor year 3 (ana)

Module na	Module name							
Intro	oduction to Re	presentation Th	eory					
Module								
no.	Credit Points	Workload	Self-study	Duration	Frequency			
04-10- 0558/de	5 CP	150 h	105 h	1 Semester	Irregular			

Lan	nguage of Instr	uction	Per	rson responsible for the Module					
Ger	rman		Pro	f. Dr. rer. nat. Nils S	Scheithauer				
1	Courses of the	e Module							
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week			
	04-10-0558-vu	Introduction to Representat Theory	ion	0	Lecture and Exercise	3			
2	-	t ns of finite groups, charact estions, projective represer	-	-		•			
3	in the course.	comes understand and are able to They have a basic underst e able to recognise the trea	andi	ng of the represent	ation theory of	finite			
4	Requirements for Participation recommended: Introduction to algebra								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)								
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.								
6	Requirements Passing the Fa	s on the Award of Credit chprüfung	Poin	nts					
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination,								
		:: 100%, Standard)		,, ***		,			
8	Usability of the B.Sc. Mathema	ne Module atik, M.Sc Mathematik, M.	Sc. N	Mathematics					
9	Literature Serre: Linear representations of finite groups, Springer Thomas: Representations of finite and Lie Groups, Imperial College Press Isaacs: Character theory of finite groups, Dover								

	Fulton, Harris: Representation theory, Springer
10	Comment
	recommended: Mathematics: Bachelor year 3 (alg)

Mod	dule na	me								
	Ellip	tic Curv	es .							
no. 04-1	Module no. Credit P 04-10- 0559/de		Points 5 CP	Workload 150 h	Self	- study 105 h	Duratio 1 Seme		Frequency Irregular	
Language of Instruction German				son respons . Dr. rer. nat				r		
1	Course	es of the	e Modul	le	l .					
Course no. Course name Workload (CP) Form of Teaching		_	Contact Hours per Week							
	04-10-0)559-vu	Elliptic	Curves		0		Lectur Exerci		3
3	Study Content Projective curves, Bezout's Theorem, Weierstrass equations, j-invariant, group law, Mordell-Weil group, elliptic curves over finite fields, torsion, Mordell's Theorem, complex uniformization. Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of the theory of elliptic curves - are able to recognise the treated concepts in various fields of mathematics.									
4	_			rticipation ex Analysis, Introd	luctic	n to Algebra	a			
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
	test, ex	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam								

	is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature A. Knapp: Elliptic curves; J. Silverman: Rational points on elliptic curves; J. Silverman: The arithmetic of elliptic curves
10	Comment recommended: Mathematics: Bachelor year 3 (alg)

Mod	dule na	me									
	Elliptic Curves										
Module no. 04-10- 0559/en		Credit	Credit Points 5 CP		Self	-study 105 h		Duration 1 Semester		Frequency Irregular	
Language of Instruction English						Person responsible for the Module Prof. Dr. rer. nat. Jan Hendrik Bruinier					
1	Course no. Course r				Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-10-0)559-vu	Elliptic	Curves		0		Lectur Exerci		3	
2	Study Content Projective curves, Bezout's Theorem, Weierstrass equations, j-invariant, group law, Mordell-Weil group, elliptic curves over finite fields, torsion, Mordell's Theorem, complex uniformization.										

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop a basic level of understanding of the theory of elliptic curves
- are able to recognise the treated concepts in various fields of mathematics.

4 Requirements for Participation

recommended: Complex Analysis, Introduction to Algebra

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature

A. Knapp: Elliptic curves;

J. Silverman: Rational points on elliptic curves;

J. Silverman: The arithmetic of elliptic curves

10 Comment

recommended: Mathematics: Bachelor year 3 (alg)

Module na	Module name						
Arit	hmetic Geome	try I					
Module	Credit Points	Workload	Self-study	Duration	Frequency		

no. 04-1	-		5 CP	150 h		105 h	105 h 1 Semester Irregular			
	~ ~	of Instru			Person responsible for the Module Prof. Dr. rer. nat. Torsten Burkhard Wedhorn					
1	Course	es of the	e Modul	le	•					
	Course no.		Course	Course name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)560-vu	Arithme	tic Geometry I		0	Lecture and Exercise			3
2	Study Content Moduli spaces, deformation theory, moduli spaces of curves, moduli spaces of abelian varieties									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an intermediate level of understanding of arithmetical geometry									
4	Requirements for Participation recommended: Algebraic Geometry									
5	Form of Examination Final Module Examination:									
	•	Modul Standa		nation (Technical	Exar	nination, or	al / writt	en Ex	aminati	on,
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	_		on the	Award of Credit	Poin	ts				
7	Gradin Final M	Iodule I Modul		nation (Technical	Exar	nination, or	al / writt	en Ex	aminati	on,
8	Weight: 100%, Standard) Usability of the Module B.Sc Mathematik, M.Sc. Mathematics									

9	Literature
	M. Olsson: Algebraic Stacks, AMS G. Laumon: Champs algebriques, Springer J. de Jong, etal: Stacks project, http://stacks.math.columbia.edu/
10	Comment recommended: Mathematics: Master (alg)

Module name										
	Intro	ductio	n to Lie	e Algebras						
no. 04-1	Module no. Credit Points 04-10- 5 CP 0561/en		Workload 150 h	•		Duration 1 Semester		Frequency Irregular		
Language of Instruction English						son respons f. Dr. rer. na				
1	Course no. Course name					Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-10-0561-vu Introduction to Lie Algebras 0 Lecture and Exercise						-	3		
2	Study Content Semisimple Lie algebras, Cartan subalgebras, root systems, structure theory of semisimple Lie algebras, basic principles of the representation theory of semisimple Lie algebras									
3	The stu	ng Outo ıdents k represer	now the	e structure theory heory.	of se	misimple Lie	e algebra	s and	the basi	c concepts
4	_	rements mended		rticipation a						
5	_	of Exam Module I								
	•	Modul Standa		ination (Technical	Exai	mination, or	al / writ	ten Ex	aminati	on,
	_	_		al Examination): Ue are only a small		•				

exam can be taken in the form of an oral exam. The decision about the form of the exam

	is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Serre: Complex semisimple Lie algebras, Springer Humphreys: Introduction to Lie algebras and representation theory, Springer Bourbaki: Lie groups and Lie algebras, Springer Carter: Lie algebras of finite and affine type, Cambridge University Press
10	Comment recommended: Mathematics: Bachelor year 3 (alg)

Module name												
Introduction to Representation Theory												
Module no. 04-10- 0562/en		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular			
Lan Eng	guage c lish	of Instru	action		Person responsible for the Module Prof. Dr. rer. nat. Nils Scheithauer							
1	Course	es of the	e Modu	le								
	Course	Course no. Course name		e name		Workload	(CP)	Form of Teaching		Contact Hours per Week		
	04-10-0)562-vu	Introdu Theory	ction to Representat	ion	0		Lectur Exerci		3		
2	Study Content Representations of finite groups, characters, induced representations, group algebra, rationality questions, projective representations, representations of compact groups											

3 Learning Outcomes

The students understand and are able to apply the notions, methods and results treated in the course. They have a basic understanding of the representation theory of finite groups and are able to recognise the treated concepts in various fields of mathematics.

4 Requirements for Participation

recommended: Introduction to algebra

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Serre: Linear representations of finite groups, Springer

Thomas: Representations of finite and Lie Groups, Imperial College Press

Isaacs: Character theory of finite groups, Dover Fulton, Harris: Representation theory, Springer

10 Comment

recommended: Mathematics: Bachelor year 3 (alg)

Module n	ame					
Мо	dular Forms	-		_		
Module	Credit Points	Workload	Self-study	Duration	Frequency	

	o. 5 CP 4-10- 563/de				1	105 h	1 Seme	ester	Irregul	ar		
	guage (man	of Instru	action			son respons f. Dr. rer. na				r		
1	Course	es of the	e Modul	e								
	Course	e no.	Course	name	Workload (CP)			Form Teac	-	Contact Hours per Week		
	04-10-0563-vu Modular Forms					0		Lectur Exerci		3		
2	Modular group, modular forms, valence formula, the algebra of modular forms, Eisenstein series, theta series, Hecke operators, L-functions, sums of squares											
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of the theory of modular forms - are able to recognise the treated concepts in various fields of mathematics.											
4	_			ticipation ex Analysis, Einfü	hrun	g in die Alge	bra					
5	_		ination Examinat	tion:								
	•	Modul Standa		nation (Technica	l Exa	mination, or	al / writ	ten Ex	aminati	on,		
	test, ex exam c is taken	ccept when an be to an be to	nen there aken in ti ommunic	al Examination): are only a small the form of an ora cated during the students taking t	num al exa first t	ber of poten m. The decis wo weeks of	tial part sion abo	icipant ut the	s. In thi	is case, the the exam		
6	_		on the	Award of Credit	Poir	nts						
7	Gradir Final M	U	Examina	tion:								
	•			nation (Technica) Standard)	l Exa	mination, or	al / writ	ten Ex	aminati	on,		
8	Usabil	ity of th	e Modu	le								

	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Freitag, Busam: Funktionentheorie 1; Serre: A course in arithmetic; A. Knapp: Elliptic curves
10	Comment recommended: Mathematics: Bachelor year 3 (alg)

Mod	lule na	me								
	Mod	ular Fo	rms							
no. 04-1	Module no. Credit Points 04-10- 5 CP 0563/en		Workload 150 h	•		Duratio 1 Semes		Frequency Irregular		
Language of Instruction English						on respons Dr. rer. na				r
1	Course no. Course			le e name	Workload ((CP)	CP) Form o Teachin		Contact Hours per Week
	04-10-0563-vu Modular Forms			r Forms		0		Lecture and Exercise		3
2	Modula	-	o, modu	lar forms, valence a series, Hecke ope		, ,				,
3	Studen - under - devel	rstand a op a bas	nd are a sic level	able to apply the n of understanding the treated conce	of the	e theory of r	nodular	forms		the course
4	Requirements for Participation recommended: Complex Analysis, Einführung in die Algebra									
5	_	of Exam Iodule I								

• Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature

Freitag, Busam: Funktionentheorie 1;

Serre: A course in arithmetic; A. Knapp: Elliptic curves

10 Comment

recommended: Mathematics: Bachelor year 3 (alg)

Mod	Module name												
	Arithmetical Geometry II												
Module no. 04-10- 0564		Credit	Points 5 CP	Workload	150 h			Duration 1 Semester		Freque Irregula	•		
		of Instru d Englisi				Person responsible for the Module Prof. Dr. rer. nat. Torsten Burkhard Wedhorn							
1	Course	es of the	e Modul	le									
	Course no.		Course	Course name			Workload	` '		n of hing	Contact Hours per Week		
	04-10-0)564-vu	Arithme	tical Geomet	ry II		0		Lectur	e and	3		

	Exercise									
2	Study Content algebraic stacks, quotient stacks, Artin criteria									
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of arithmetical geometry - are able to extend their knowledge in this field									
4	Requirements for Participation recommended: Algebraic Geometry									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and									
	communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	Requirements on the Award of Credit Points Passing the Fachprüfung									
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics									
9	Literature M. Olsson: Algebraic Stacks, AMS G. Laumon: Champs algebriques, Springer J. de Jong, etal: Stacks project, http://stacks.math.columbia.edu/									
10	Comment recommended: Mathematics: Master (alg)									

Mod	lule na	me									
	Real	and co	mplex	manifolds							
Mod no. 04-1 056		Credit Points 9 CP		Workload 270 h	Self	- study 180 h	Duration 1 Semester		Frequency Irregular		
	guage o	of Instru	ıction			son respons				ckmann	
1	Course	s of the	e Modu	le							
	Course	e no.	Cours	e name	` ,			Form Teac		Contact Hours per Week	
	04-10-0565-vu Real and complex manifolds 0 Lecture and 6 Exercise										
3	Prerequisites from Point-set topology: compactness, continuity, Hausdorff property, relative topology. Algebraic topology: connectedness, fundamental group, coverings. Manifolds: Differentiability, tangent bundle, submanifolds. Integration of differential forms and Stokes theorem. Further topics such as Riemann surfaces, vector fields and Frobenius theorem. Learning Outcomes										
				rhich concepts of real		-	•		e invaria	nntly	
4	recomr	nended	: Analys		com	plex analysi	s, ordina	ry diff	erential		
5	recommended: Analysis, Linear Algebra, complex analysis, ordinary differential equations, integration. Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.										
6	Requir	ements	on the	Award of Credit	Poin	ts					

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Lee: Introduction to smooth Manifolds Warner: Foundations of differentiable manifolds and Lie groups Farkas, Kra: Riemann surfaces
10	Comment recommended: Mathematics: Bachelor year 3 (geo)

Mod	Module name											
	Selected Topics in Optimization											
Mod no. 04-1 056		Credit Points 5 CP		Workload 150 h		- study 105 h	Duration 1 Semester		Frequency Irregular			
	•	of Instru d Englis				son respons . Dr. rer. nat						
1	Course	es of the	e Modu	le					•			
	Course no. Course		e name	name		(CP)	Form of Teaching		Contact Hours per Week			
	04-10-0)566-vu	Selected	d Topics in Optimiza	ition	0		Lecture and Exercise		3		
2	-	Contending on					,					
3	Studen - under - devel	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in optimization - are able to extend their knowledge in this field										

	- are able perform supervised research in this field
4	Requirements for Participation recommended: depending on topic, at least Introduction to Optimization
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment recommended: Mathematics: Master (opt)

Module name										
Selected topics in geometry and approximation										
Mod no.	lule	Credit Points	Workload	Self-study	Duration	Frequency				
04-1 056		5 CP	150 h	105 h	1 Semester	Irregular				
Language of Instruction				Person responsible for the Module						
German and English				Prof. Dr. rer. nat. Ulrich Reif						
1	Courses of the Module									

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
	04-10-0567-vu	Selected topics in geometry and approximation		Lecture and Exercise	3
_					

2 Study Content

To mention but some examples:

- * Spline approximation of PDEs
- * Non-linear subdidivsion
- * Approximation and smoothing of manifold-valued data
- * Image processing
- * Wavelets
- * harmonic maps
- * relativity theory
- * geometric partial differential equations
- * Lie groups, etc.

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop an advanced level of understanding of a specific topic in geometry or approximation
- are able to extend their knowledge in this field
- are able perform supervised research in this field

4 Requirements for Participation

recommended: typically Differential geometry

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

Module Examination (Technical Examination, oral / written Examination,
 Weight: 100%, Standard)

8	Usability of the Module
	M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Master (geo)

Mod	lule na	me								
	Sele	cted to	pics in	geometry and a	opro	ximation				
Module no. Credit			Workload		f-study Durat			_	Frequency	
04-1 056		9 CP 270 h			180 h	1 Seme	ster	Irregu	lar 	
						son respons Dr. rer. na			odule	
1	Course	es of the	e Modu	le	•					
	Course no. Course name Workload (CP) Form of Teaching		_	Contact Hours per Week						
	04-10-0)568-vu	Selected approxi	l topics in geometry mation	and	0		Lectur Exerci	-	6
2	To mer * Splin * Non- * Appr * Imag * Wave * harm * relati * geon	e approllinear substitution oximation oximatio	t some ximatioubdidivs on and sessing aps ory	examples: n of PDEs sion smoothing of mani		valued data				
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in geometry or approximation - are able to extend their knowledge in this field									

	- are able perform supervised research in this field
4	Requirements for Participation
	recommended: typically Differential geometry
5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written
	test, except when there are only a small number of potential participants. In this case, the
	exam can be taken in the form of an oral exam. The decision about the form of the exam
	is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
	prospective number of students turing the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Master (geo)

Mod	dule na	ame					
	Clas	s field theory					
Mod no.	dule	Credit Points	Workload	Self-study	Duration	Frequency	
04-1 056		5 CP	150 h	105 h	1 Semester	Irregular	
		of Instruction ad English		Person responsible for the Module Prof. Dr. rer. nat. Jan Hendrik Bruinier			
1	Courses of the Module						

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week		
	04-10-0569-vu	Class field theory	0	Lecture and Exercise	3		
2	Study Content Cohomology of finite groups, local class field theory, local reciprocity law, global class field theory, global reciprocity, ideles, idele class group						
3	- develop an ac	comes Indicate able to apply the notion dvanced level of understanding tend their knowledge in this form supervised research in this	g of the theory of cla ield		he course		
4	_	s for Participation : Algebraic Number Theory					
5	Standa Fachprüfung (' test, except wheexam can be taken and co	Examination: e Examination (Technical Exa	lly the exam is taken ber of potential part m. The decision abo wo weeks of the lect	in form of a w icipants. In this ut the form of	ritten s case, the the exam		
6	Requirements Passing the Fac	s on the Award of Credit Poir chprüfung	its				
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)						
8	Usability of the B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M.Sc. N	Mathematics				
9	Literature N. Childress: Class field theory; D. Cox: Primes of the form x^2+ny^2; J. Neukirch: Algebraische Zahlentheorie; J. Milne: Class Field Theory;						

	J. Neukirch: Klassenkörpertheorie
1	Comment recommended: Mathematics: Master (alg) Selected topic in number theory

Mod	lule na	me								
	Linea	ar Alge	braic G	roups						
Mod no. 04-1	.0-	Credit	Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular	
		of Instru d Englisi				son respons . Dr. rer. na				edhorn
1	Course	es of the	e Modul	le		_				
	Course no. Cours		Course	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-10-0)570-vu	Linear A	Algebraic Groups		0		Lectur Exerci		3
2	•	Conten algebra		os as matrix groups	s, stru	acture theor	y, classif	ication	1	
3	Studen - under - devel - are al	estand a op an ac ole to ex	nd are a dvanced atend the	able to apply the nate of understand the second of the second research in the second of the second of the second in the second of the second o	nding his fi	g of the theo eld				
4	_			rticipation aic Geometry						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the									

	exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature A. Borel: Linear algebraic groups, Springer T. Springer: Linear algebraic groups, Birkhäuser
10	Comment recommended: Mathematics: Master (alg) Selected topic in algebraic geometry

Mod	dule nar	ne								
	Selec	ted To	pics in	Computational I	_ogic					
Module no. 04-10- 0571/en		Credit	Credit Points Workload 5 CP 150 h			F-study Duration 105 h 1 Semester			Frequency Irregular	
Lan Eng	guage o	f Instru	action			son respons . Dr. phil. na				
1	Course	s of the	e Modul	le						
	Course	no.	Course	e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-10-0	571-vu		l Topics in ational Logic		0		Lectur Exerci		3
2	Study (Conten	t							
	-	_		ructor, this course n higher types, ga			-			•

Learning Outcomes 3 Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in computational logic - are able to extend their knowledge in this field - are able perform supervised research in this field **Requirements for Participation** recommended: depending on topic 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 6 Requirements on the Award of Credit Points Passing the Fachprüfung 7 Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) **Usability of the Module** B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics 9 Literature depending on topic 10 Comment recommended: Mathematics: Master (log)

Module name								
Sele	cted Topics in	Logic and Comp	lexity					
Module	Credit Points	Workload	Self-study	Duration	Frequency			

no. 04-1 0572	.0- 2/en		5 CP	150 h		105 h	1 Semes	ster	Irregul	ar
Lang Engl		of Instru	ıction			son respons . Dr. rer. na			odule	
1	Course	es of the	e Modul	le						
	Course no. Course name			e name		Workload	Form of Teaching		Contact Hours per Week	
	04-10-0)572-vu	Selected Comple	l Topics in Logic an xity	d	0		Lectur Exerci		3
2	selecte algorith	hmic co ucture a	revolvii mplexity nd com	ng around fundan y of problems fror plexity theoretic c s theoretical con	n logi lassif	c and/or the	e analysis	s by lo	gical m	ethods of
3	Studen course. logic as allows	They h	rstand a ave dev plexity to conduc	and are able to appeloped an advance heory. They are a related research	ed lev	vel of unders extend thei	standing r knowle	of a sp	pecific t	opic in
4	_			ling on topic						
5		-	ination Examina							
	•	Modul Standa		nation (Technica	l Exar	nination, or	al / writt	en Exa	aminati	on,
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.						is case, the the exam			
6	-		on the	Award of Credit	Poin	ts				
7	Gradin Final M	Iodule I Modul		ition: ination (Technica Standard)	Exar	nination, or	al / writt	en Exa	aminati	on,

8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	
10	Comment
	recommended: Mathematics: Master (log)

Mod	lule na	me								
	Sele	cted To	pics in	Logic and Found	latio	ns				
Mod no. 04-1		Credit	Points 5 CP	Workload 150 h	Self	- study 105 h	Duratio 1 Seme		Freque Irregula	•
Lan Eng	0	of Instru	action			son respons . Dr. rer. nat				
1	Course		Cours	e name		Workload	(CP)	Form	-	Contact
								Teac	hing	Hours per Week
	04-10-0)573-vu	Selected Founda	l Topics in Logic and tions	d 0			Lecture and 3 Exercise		3
2	Depend		the lec	turer there will be omotopy type theo						/pe
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in logic and its foundations - are able to extend their knowledge in this field - are able perform supervised research in this field									
4	Requirements for Participation recommended: depending on topic									
5	_		ination Examina							

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

depending on topic

10 Comment

recommended: Mathematics: Master (log)

Mod	dule na	me								
	Stati	stics fo	r stoch	astic processes						
Module no. 04-10- 0574		Credit	Points 9 CP	Workload 270 h	Self-study 180 h		Duratio 1 Semes		Freque Irregula	•
	guage o	d Englis	h	lo.		con respons				
1	Course no. Course		e name		Workload	(CP)	Form Teac	-	Contact Hours per Week	
	04-10-0)574-vu	Statistic	es for stochastic		0		Lectur Exerci	-	6

2 Study Content

Weak convergence in Polish spaces, Theory of convergence in $(C(0,1), \sup)$, Theorem of Donsker, Parametric statistical methods for queueing systems, Theory of Bayes, Nonparametric statistical approaches for stochastic networks, theorems of functional convergence

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop an advanced level of understanding of statistical methods for stochastic processes
- are able to extend their knowledge in this field
- are able perform supervised research in this field

4 Requirements for Participation

recommended: Mathematical Statistics

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Klenke, Wahrscheinlichkeitstheorie Billingsley, Converngence of probability measures

10 Comment

recommended: Mathematics: Master (sto)

Mod	lule na	me										
	Stoc	hastic p	rocess	es IIB	1		·		Ī			
Mod no. 04-1 057	LO-	Credit	Points 9 CP	Workload 270 h	Self	-study 180 h	Duratio 1 Semes		Freque Irregula	-		
		of Instru			Person responsible for the Module Prof. Dr. rer. nat. Volker Martin Betz							
1	Course	es of the	e Modul	le		_						
	Course no. Course		e name		Workload (CP)		Form Teac	_	Contact Hours per Week			
	04-10-0)575-vu	Stochas	tische Prozesse IIB		0		Lectur Exerci		6		
2	Study Content statistical mechanics and interacting particle systems: Feller processes, continuous time Markov chains, Gibbs measures, scaling limits, models and results from statistical mechanics.											
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of the theory of stochastic processes - are able to extend their knowledge in this field - are able perform supervised research in this field											
4	-			rticipation stic Processes I								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.											
6	Requir	ements	on the	Award of Credit	Poin	ts						

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematiks
9	Literature Liggett: interacting particle systems Friedli, Velenik: Statistical mechanics of Lattice Systems
10	Comment recommended: Mathematics: Master (sto)

Mod	dule na	me								
	Stoc	hastic բ	orocess	es IIC						
Mod	dule	Credit	Points	Workload	Self-	-study	Duratio	on	Frequency	
04-1 057		9 CP	270 h		•	1 Seme	ster	Irregul	•	
		of Instru	uction		Pers	son respons	ible for	the M	odule	
Ger	man and	d Englis	h		Prof	Dr. rer. na	t. Frank	Aurza	da	
1	Course	es of the	e Modu	le	•					
	Course no.		Course name			Workload (CP)		Forn Teac		Contact Hours per Week
	04-10-0576-vu Stochas			stic processes IIC		0		Lectur Exerci		6
2	Study Content current topics in stochastic processes, e.g.: presistence probabilities, first passage times, branching processes, limit theorems, strong approximation, long range dependence, coding theory.									
3	Learning Outcomes Students									
 understand and are able to apply the notions, methods and results treated in the cour develop an advanced level of understanding of the theory of stochastic processes are able to extend their knowledge in this field 										

	11 6 11 11 011
	- are able perform supervised research in this field
4	Requirements for Participation
	recommended: Stochastic Processes I
5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written
	test, except when there are only a small number of potential participants. In this case, the
	exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the
	prospective number of students taking the exam.
	Prospective manner of statutous tamano are cramin
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
8	Usability of the Module
	B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Master (sto)

Mod	Module name													
	Stochastic processes IID													
Mod no.	dule	Credit Points	Workload	Self-study	Duration	Frequency								
04-1 057		9 CP	270 h	180 h	1 Semester	Irregular								
Lan	guage	of Instruction		Person responsible for the Module										
Ger	man an	nd English		Prof. Dr. rer. nat. Volker Martin Betz										
1	Courses of the Module													

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-10-0577-vu	Stochastic processes IID	0	Lecture and Exercise	6				
2	Brownian mot	erential equations and roug ion, Stratonovich and Ito ro lutions to rough differentia	ough paths, existence a	nd continuity o	of rough				
3	- develop an ac	comes and are able to apply the nor dvanced level of understance ktend their knowledge in the form supervised research in	ling of the theory of stories field						
4	_	s for Participation : Stochastic Processes I							
5	Standa Fachprüfung (test, except wh exam can be ta	Examination: le Examination (Technical E	sually the exam is taken umber of potential par exam. The decision abo	n in form of a v ticipants. In th out the form of	written is case, the the exam				
		imber of students taking the		rare, pasea on					
6	Requirements Passing the Fa	s on the Award of Credit P chprüfung	oints						
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)								
8	Usability of th B.Sc Mathema	ne Module tik, M.Sc. Mathematik, M.S	c. Mathematics						
9	Literature Friz, Hairer: A	course on rough paths							

10 Comment

recommended: Mathematics: Master (sto)

Mod	dule na	ma								
WIOC										
		hastic p	orocess	es IIE			<u> </u>		I	
Mod no. 04-1	10-	Credit	Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Seme		Freque Irregul	*
057										
	guage o					son respons				
	man and				Dr.	rer. nat. Cor	nena wi	cneina	ıus	
1			e Modul			TAT 11 1	(CD)	T_	<u> </u>	
	Course no. Course n			e name		Workload	(CP)	Form Teac		Contact Hours per Week
	04-10-0	578-vu	Stochas	tic processes IIE		0		Lectur Exerci		6
3	- stocha Learni Studen - under - devel applica - are al	ng Outous ts stand a op an actions of	comes nd are a dvanced various stend the	e series and importy systems: models and able to apply the national level of understand a stochastic procession in the stochastic pr	otion nding ses his fi	as, methods as of the theo	and resu			
	- are al	ole to pe	erform s	upervised researcl	ı ın t	his field				
4	_			rticipation stic Processes I						
5	Form of Examination Final Module Examination:									
	•	Modul Standa		ination (Technical	Exar	nination, or	al / writ	ten Exa	aminati	on,
	_	_		al Examination): Ue are only a small		-				

	exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Klenke: Wahrscheinlichkeitstheorie Daley, Vere-Jones: An Introduction to the Theory of Point Processes Asmussen: Applied Probability and Queues
10	Comment recommended: Mathematics: Master (sto)

Mod	dule na	me									
	Com	putatio	nal Co	mplexity							
Mod no. 04-1		Credit Points 9 CP		Workload 270 h	Self-study 180 h		Duration 1 Semester		Frequency Irregular		
Language of InstructionPerson responsible for the ModuleGerman and EnglishDr. rer. nat. Kord Eickmeyer											
1	Courses of the Module										
	Course no. Cours		e name		Workload (CP)		Form Teac		Contact Hours per Week		
	04-10-0)579-vu	Comput	ational Complexity		0		Lectur Exerci		6	
2											

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop an advanced level of understanding of computational complexity theory
- are able to extend their knowledge in this field

4 Requirements for Participation

recommended: linear algebra

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Sanjeev Arora, Boaz Barak: Computational Complexity, Cambridge University Press; Christos Papadimitriou: Computational Complexity, Pearson; Vijay Vazirani: Approximation Algorithms, Springer; Jörg Flum, Martin Grohe: Parameterized Complexity; Springer

10 Comment

recommended: Mathematics: Bachelor year 3 (log)

Module Description

Module name

Selected Topics in Algebra

Mod no. 04-1 058		Credit	Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Semes		Frequency Irregular	
		of Instru d Englis				on respons Dr. rer. na				edhorn
1	Course	es of the	e Modu	le		T		T		
	Course	e no.	Cours	e name		` ′			Form of Control House Per W	
	04-10-0)580-vu	Selected	l Topics od Algebra		0		Lectur Exerci		6
2	Study Content Current topic in algebra, for instance Linear Algebraic Groups, proetale cohomology, Lie groups and Lie algebras, Adic Spaces, Arakelov Intersection Theory, Moduli Spaces									
3	Learning Outcomes After attending this course, students will know a current research field within algebra									
4	_			rticipation a, Analysis, Algebr	raic C	eometry or	Algebrai	c Num	iber The	eory
5		of Exam Iodule I								
	•	Modul Standa		ination (Technical	Exar	nination, or	al / writt	en Exa	aminati	on,
	test, ex exam o	ccept when an decept and be taken	nen ther aken in ommuni	al Examination): It e are only a small the form of an oracated during the factorial students taking the	num l exai irst tv	ber of poten m. The decis wo weeks of	tial parti sion abou	cipant it the	s. In thi	is case, the the exam
6	_	ements g the Fa		Award of Credit	Poin	ts				
7	Grading Final Module Examination:									
	 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 									on,
8		ity of th Mathem		ile Sc. Mathematics						

9		Literature differs
1	-	Comment recommended: Mathematics: Master year 1 or 2

		SCIIPU								
Moc	lule na	me								
	•	ratoral	gebraic	Probability The	ory		ı		ī	
no.	04-10- 9 CP		Workload 270 h	Self	- study 180 h	Duratio 1 Seme		Frequency Irregular		
Lan	guage o	of Instru d Englis				son respons . Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no. Course		e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-10-0)581-vu	Operato Theory	oralgebraic Probabili	ty	0		Lectur Exerci		6
	Study Content - Spectral theoy - operator algebras - tensor products - completely positive operators - quantum systems - classical and quantum stochastic processes - classical and quantum dynamical systems									
3	Learning Outcomes Students know and understand the concepts, methods, and results taught and can apply them. They have a deeper understanding of subareas of operator algebras and quantum probability theory, depending on the specific topics. They are able to augment their knowledge in this area independently and to pursue research questions in it under guidance.									
4	Requirements for Participation Functional analysis and, depending on the specific topics, parts probability theory, stochastic processes, quantum mechanics									
5	Form o	of Exam	ination	1						

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B. Sc. Mathematik, M. Sc. Mathematik, M.Sc. Mathematics

9 Literature

M. Takesaki: Theory of Operator Algebras I, II, III

B. Blackadar: Operator Algebras

D. Applebaum et al.: Quantum Independent Increment Processes I,II

Further literature depending on the topics

10 Comment

More detailed information on the choice of topics, requirements and literature can be found at the beginning of the semester in TUCaN.

Mod	Module name										
	Selected Topics of Geometry										
Module no. 04-10- 0582		Credit	Points 5 CP	Workload	150 h		- study 105 h	Duratio 1 Semes		Frequency Irregular	
Lan	guage (of Instru	ıction			Person responsible for the Module					
Ger	man and	d Englisl	h			Prof. Dr. rer. nat. Karsten Große-Brauckmann					
1	Courses of the Module										
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours

					per Week				
	04-10-0582-vu	Ausgewählte Themen der Geometrie	0	Lecture and Exercise	3				
2	Study Content								
3	Learning Outcomes Students have studied a specific topic of the research area Geometry and Approximation and can apply their insights to solve problems.								
4	_	Requirements for Participation as specified by lecturer							
5	Form of Exam Final Module I								
	Module Examination (Technical Examination, oral / written Examination, Standard)								
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.								
6	Requirements Passing the Fa	s on the Award of Credit P chprüfung	oints						
7	Grading Final Module I	Examination:							
		le Examination (Technical E :: 100%, Standard)	Examination, oi	ral / written Examinati	on,				
8	Usability of the	ne Module tik, M.Sc. Mathematik, M.Sc	c Mathematics						
9	Literature to be specified	in class							
10	Comment recommended	for Master							

Module name										
	Selected Topics in Numerics 2									
Mod no. 04-1 058		Credit Points 5 CP		Workload 150 h	Self	f- study 105 h	Duration 1 Semester		Frequency Every 2. semester	
	guage o	of Instru	action			son respons f. Dr. rer. na			odule	
1	Course	es of the	e Modu	le	•					
			e name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)583-vu	Selected	l Topics in Numerics	s 2	0		Lectur Exerci		3
2	Study Content Topic dependent, examples include: - Analysis and numerics of singularly perturbed problems									
3	Learning Outcomes Students know and understand the terms, methods and results given under learning content and can apply them. They have a deepened understanding of an area of the theory of numerics. They are able to expand their knowledge in this area independently and to pursue research questions in it under guidance.									
4	_			rticipation certification of pr	ereqı	uisites is pos	sible)			
5		of Exam Iodule I								
	•	Modul Standa		ination (Technical	Exai	mination, ora	al / writ	ten Exa	aminati	on,
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	Requir	ements	on the	Award of Credit	Poin	its				

7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module recommended: Mathematics: Master (num)
	recommended: Mudicinaties: Musici (muni)
9	Literature
	depending on topic
10	Comment

Mod	dule na	-								
Moo no. 04-1	dule 10-	Credit Points 6 CP			Self-study 120 h		Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction P						son respons f. Dr. rer. na				
1 Courses of the Module										
				e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)594-vu	Statistik	I für Cognitive Scie	ence	0		Lecture and Exercise		4
2	Study Content descriptive statistics (collecting and representing data, histogram); theory of probability (random variables, combinatorics, distribution and their moments); estimators (samples, central limit theorem. point and interval estimators); testing (hypothesis testing, significance, error of the first and second kind, chi-square test, distribution testing)									
3		ng Outo tlung ei		ten Grundlagenwi	ssens	s in der math	nematisc	hen St	atistik	
		•		idungen unter Uns						rischem
				chem Management			ŕ			
	Die Stu	ıdierend	len solle	en typische statistis	sche	Probleme de	s Schätz	ens ur	nd	

	Testens in technischen, betriebswirtschaftlichen und ökonomischen Fragestellungen erkennen, an Nichtfachleute kommunizieren und für tiefergehende Analysen von Spezialisten aufbereiten können.
4	Requirements for Participation keine
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Pflicht
9	Literature Bamberg, G., Bauer, F., Krapp, M.: Statistik, 13. Aufl., Oldenbourg, München, 2007 Fahrmeir, L., Künstler, R., Pigeot, I. Tutz, G.: Statistik -Der Weg zur Datenanalyse. 4. Aufl., Springer, Berlin 2003 Schira, J., Statistische Methoden der VWL und BWL: Theorie und Praxis, 2. Aufl., München usw., Pearson Studium, 2005
10	Comment Verantwortlich: Herr Aurzada (sto)

Mod	Module name								
	Algebraic Topology								
Mod no. 04-1 058	L O -	Credit Points 9 CP	Workload 270 h	Self-study 180 h	Duration 1 Semester	Frequency Irregular			
Lang Engl	lish	of Instruction	le.	Person responsible for the Module Prof. Dr. rer. nat. Torsten Burkhard Wedhorn					

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-10-0585	Algebraic Topology	0	Lecture and Exercise	6				
2	Study Content Basic of Algebraic Topology: Homotopy, fundamental groupoid, homology, cohomology, fibrations								
3	Learning Outcomes The students learn to cope with the basics of algebraic topology								
4	Requirements for Participation Recommended: Linear Algebra, Analysis, Introduction to Algebra								
6	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. Requirements on the Award of Credit Points Passing the Fachprüfung Grading								
	 Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 								
8	Usability of th M.Sc Mathema	ne Module ntik, M.Sc. Mathematics, LAG M	Mathematik						
9	Literature P. May: Concis	se Algebraic Topology; tom Die	ck: Algebraic Topolo	egy					
10	Comment								

Mod	Module name									
	Mathematical Statistical Mechanics									
Mod no. 04-1 058	Credit Points 9 CP		Workload 270 h		- study 180 h	Duration 1 Semester		Frequency Irregular		
	Language of Instruction English					son respons . Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no. Course name		e name	Workload (C		(CP)	Form of Teaching		Contact Hours per Week	
	04-10-0)586	Mathem Mechan	natical Statistical ics		0		Lectur Exerci		6
	Study Content We will study models for spatially extended systems of many interacting particles that are subject to noise. The most prominent example is the Ising model, but we will also consider other models like the Potts model. For these models, we will consider the question of infinite volume limits, phase transitions, correlation inequalities, thermodynamic variables, and alternative (e.g. Random walk) representations.									
3	In this microse simple these of	copic ef cases. Y	you wil fects, an You will e very d	l learn how macro nd how mathemati learn to use and fi lifficult problems. T the field.	cs ca	n describe a orrelation in	nd prove equalitie	this pes, a ke	henome ey tool to	enon in o study
4	_			rticipation Wahrscheinlichkei	tsthe	orie				
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam									
	exam o	an be tan and co	aken in 1 ommuni	· · · · · · · · · · · · · · · · · · ·	l exa irst tv	m. The decis wo weeks of	ion abou	it the	form of	the e

6	Requirements on the Award of Credit Points Passing the Fachprüfung;
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature 1) Sacha Friedli and Yvan Velenik: Statistical Mechanics of Lattice Systems, Cambridge University Press 2017. 2) Hugo Duminil-Copin: Graphical Representations of Lattice Spin Models, availabe from his home page.
10	Comment

Module name										
Computational Electromagnetics										
Module no. 04-10-		Credit Points 9 CP		Workload 270 h		-study Duratio		1		•
Language of Instruction English					Person responsible for the Module PD Dr. Kersten Schmidt					
1	Course	s of the	e Modul	le		T				1
Course no.			Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0	587-vu	Comput Electror	ational nagnetics		0 Lect Exer			re and ise	6
2	Study Content Formulation of problems in electromagnetics (Poisson equation, Helmholtz equation, eddy current model, Maxwell equations), variational formulation in Hilber spaces and solution theory, Galerkin discretization and Numerical Analysis									
3	Studen	_		able to apply the n	otion	s, methods a	and resu	lts trea	ated in t	he course

	- develop an advanced level of understanding of the solution theory for electromagnetic problems and Galerkin discretizations
4	Requirements for Participation
	basic knowledge in numerics and partial differential equations
5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc.Mathematik, M.Sc.Mathematics
9	Literature Monk, Finite Element Methods for Maxwell's Equations, Oxford Scientific Publications, Alonso-Rodriguez, Valli, Eddy Current Approximation of Maxwell Equations: Theory, Algorithms and Applications, Springer, Braess, Finite Elements, Springe
10	Comment

Module name											
Combinatorial Optimization											
Module											
no.	Credit Points	Workload	Self-study	Duration	Frequency						
04-10-	5 CP	150 h	150 h	1 Semester	Irregular						
0588											

Lan	guage of Instr	uction	Person responsible for the Module Prof. Dr. Yann Disser							
Eng	lish									
1	Courses of the	e Module								
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-10-0588-vu	Combinatorial Optimization	1	0	Lecture and Exercise	0				
2	Study Content shortest paths (advanced), maximum flows (advanced), min-cost maximum flows, maximum matchings, complexity									
3	Learning Outcomes The students know and understand the concepts and methods taught in the course and can apply them. They have a thorough understanding of the formal foundations of combinatorial optimization. They are able to independently expand their knowledge of the field and pursue supervised research projects. Requirements for Participation									
T	_	l: Introduction to Optimiz	ation	, ADM						
5	Form of Exam Final Module I	Examination:	Ever	nination aval / ur	itton Evominat	ion				
	Standa	le Examination (Technical) rd)	EXAI	ililiation, orar/ wr	itten Examinat	1011,				
	Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated by the instructor during the first lecture. during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	Requirements	on the Award of Credit	Poin	ts						
7	Grading Final Module I	Examination:								
		e Examination (Technical):: 100%, Standard)	Exaı	mination, oral / wr	itten Examinat	ion,				
8	Usability of th M. Sc. Mathen	ne Module natik and Mathematics, B	Sc. M	Iathematik (3rd ye	ar)					
9	Literature									

	Korte, Vygen. Combinatorial Optimization. Springer, 2012.
10	Comment

Mod	lule na	me								
	Alge	braic G	eomet	ry II						
no. 04-1	Module no. Credit Points 04-10- 9 CP 0589		Workload Self-		lf-study Duration 180 h 1 Semes		-			
Language of Instruction German and English						son respons . Dr. rer. na				edhorn
1	Course	es of the	e Modul	le						
	Course no. Course name					Workload	(CP)	Form Teac		Contact Hours per Week
	04-10-0)589-vu	Algebra	ic Geometry II				Lecture and Exercise		6
	Topics and the algebra	are loca e cohom	l and gl ology o rived fu	nuation of the lectuobal properties of f schemes, in partinctors, cohomologicality.	morı cular	phisms of sci homologica	hemes al			
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of schemes, their morphisms, and their cohomology - are able to extend their knowledge in this field - are able perform supervised research in this field									
	Requir	ements	for Pa	rticipation						
4	Recommended: Algebraic Geometry Form of Examination Final Module Examination:									

 Module Examination (Technical Examination, oral / written Examination, Standard)

Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc.Math and M.SC Mathematics

9 Literature

Hartshorne: Algebraic Geometry Grothendieck et al.: EGA and SGA Stacks Authors: The Stacks project

10 Comment

Mod	Module name										
	Non-Academic Internship										
Module no. Credit Points Workload 04-10- 5 CP 150 0590/de							- study 150 h	Duratio 1 Semes		Frequer Irregula	•
	5 5						Person responsible for the Module Studiendekan*in des Fachbereichs 04				
1	Course	es of the	Modul	le							
Course no. Course name									Form Teac		Contact Hours per Week

2	Study Content volunteering or internship in a company or a extra-academic institution in a location reflecting the potential future work environment of a mathematics student.
3	Learning Outcomes The students experience a realistic working environment for mathematicians. They can work in teams and have an idea how mathematicians may work and can report on it.
4	Requirements for Participation empfohlen: Pflichtmodule des 1. und 2. Studienjahres
	In der Regel werden Praktikumsplätze auf Eigeninitiative der Studierenden gefunden. Damit ein Praktikum anerkannt werden kann, muss es sich hinreichend für den Studiengang eignen. Die Eignung des Praktikums muss von einer Dozentin/einem Dozenten des Fachbereichs Mathematik anerkannt werden, die/der dann auch den Schein ausstellt.
5	Form of Examination Final Module Examination:
	Module Examination (Study Examination, Special Form, Standard)
	Studienleistung: Bericht und/oder Vortrag bei mitbetreuender Dozentin/mitbetreuendem Dozenten des Fachbereichs
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 0%, Standard)
	wiodule Examination (Study Examination, Special Porni, Weight, 0%, Standard)
8	Usability of the Module Bachelor Mathematik PO 2018, Studium Generale, not for Master of Science Mathematik or Mathematics
9	Literature
10	Comment

Mod	dule	name

Selected Topics in Algebra

3.6				T							
Mod no.	lule	Credit	Points	Workload	Self	-study	Duration		Frequency		
			5 CP	5 CP 150 h		105 h 1 Se				lar	
059											
		o f Instru d Englisi				on respons . Dr. rer. na				adhorn	
1		es of the		 le	FIOI	. D1. 161. 11a	. 1013161	ii buik	iiaiu vv	ediloffi	
1	Course	1		e name		Workload	(CP)	Form	Form of Cor		
	Goarse name						` ,	pe		Hours per Week	
	04-10-0)590-vu	Selected	d Topics in Algebra		0		Lectur Exerci		3	
2	Curren		n algeb	ra, for instance Linas, Adic Spaces, A							
3		ng Outo		ourse, students wil	l knov	w a current	research	field v	within a	ılgebra	
4	_			rticipation a, Analysis, Algeb	raic G	Seometry or	Algebrai	c Num	iber Th	eory	
5		of Exam Iodule E									
	•	Modul Standa		ination (Technical	l Exan	nination, or	al / writt	en Exa	aminati	on,	
	numbe oral ex during	r of pote am. The	ential pare decision t two w	ken in form of a warticipants. In this on about the form eeks of the lecture	case, of the	the exam c e exam is tal	an be tal ken and	ken in comm	the formunicated	n of an d	
6	-	rements		Award of Credit	Poin	ts					
7	Gradi r Final M	ng Iodule F	Examina	ntion:							
	 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 								on,		
8		ity of th Mathem		ale Sc. Mathematics,	LAG						
9	Literat	ure									

	to be announced at the beginning of the semester
10	Comment

<u>viou</u>	uie De	<u>scripuo</u>	<u>)11</u>							
Mod	dule na	me								
	Арр	lied Sta	tistics i	n Human Scienc	es					
Mod no. 04-1 059		Credit	Points 8 CP	Workload 240 h		-study 165 h	Duratio 1 Semes		Freque Every 2 semeste	
	guage (of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Michael Kohler					
1	Course	es of the	e Modul	le						
	Course no. Course		e name		Workload	(CP)	Form o Teachin		Contact Hours per Week	
	04-10-0)592-vu	Applied Sciences	Statistics in Human	1	0		Lectur Exerci	-	5

2 Study Content

Folgende Lerninhalte werden anhand beispielhafter humanwissenschaftlicher Fragestellungen erläutert:

- 1. Erhebung von Daten im Rahmen von Studien und Umfragen
- 2. Beschreibende Statistik
- Graphische Darstellung von Daten mit Hilfe von Säulendiagrammen, Histogrammen und Boxplots
- Statistische Maßzahlen, insbesondere Maße der zentralen Tendenz (Arithmetisches Mittel, Median) und Dispersion (Varianz, Standardabweichung und Interquartilsabstand)
- Lineare Regression, Kovarianz und Korrelation
- 3. Das mathematische Modell des Zufalls
- Der Begriff der Wahrscheinlichkeit, das empirische Gesetz der großen Zahlen
- Wahrscheinlichkeitsmaße
- Zufallsvariablen und Verteilungen
- Erwartungswert und Varianz
- Unabhängigkeit,

- Gesetz der großen Zahlen und zentraler Grenzwertsatz 4. Statistische Testverfahren - Logik von Signifikanztests (Hypothesenbildung und -formulierung, Alpha- und Betafehler, Vorgehen bei Signifikanztests, Grenzen von Signifikanzaussagen (Stichprobengröße, Effektstärke, Power)) - Statistische Tests (t-Test, F-Test, Chiquadrat-Test) 3 **Learning Outcomes** Die Studierenden verfügen über ein grundlegendes Verständnis für das Konzept des Zufalls und darauf aufbauender statistischer Schlussweisen. Sie haben ein Konzept zu statistischen Maßzahlen, der zentralen Tendenz und der Dispersion. Sie verstehen das Prinzip eines statistischen Signifikanztests, können gängige statistische Tests auf humanwissenschaftliche Fragestellungen anwenden und kennen die Grenzen von Signifikanzaussagen. Sie verstehen die Prinzipien von Korrelation und linearer Regression und können Korrelation von Kausalität unterscheiden. **Requirements for Participation** 5 Form of Examination Final Module Examination: Module Examination (Study Examination, Written Exam, Duration 90 min, Standard) **Requirements on the Award of Credit Points** 7 Grading Final Module Examination: Module Examination (Study Examination, Written Exam, Weight: 100%, Standard) Usability of the Module Literature Judith Eckle-Kohler, Michael Kohler. Eine Einführung in die Statistik und ihre Anwendungen. 3. Auflage, Springer, 2017 Comment 10

Module name										
Statistics for Economics										
Module no. 04-10- 0593		Credit Points 4 CP		Workload 120 h	Self-study 75 h		Duration 1 Semester		Frequency Every 2. semester	
Language of Instruction German			Person responsible for the Module Prof. Dr. rer. nat. Frank Aurzada							
1 Courses of the Module										
	Course no		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
04-10-0)593-vu	Statistics for Economics			0		Lecture and Exercise		3
2	Study Content Descriptive statistics, probability calculus, random variables, distributions, limit theorems, point estimation, confidence intervals, hypothesis tests									
3	Learning Outcomes After the course the students are able to • describe the basics of descriptive and inductive statistics. • conduct the main operations of probability calculus. • apply statistical estimation and testing procedures correctly. • recognize the relevance of statistical analyses for business and economic problems. • judge the results of statistical analyses and to communicate them orally and in written form correctly									
4	Requirements for Participation recommended: Mathematik I and II									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Written Exam, Duration 90 min, Standard)									
6	Requirements on the Award of Credit Points									
7	Grading Final Module Examination:									

	Module Examination (Technical Examination, Written Exam, Weight: 100%, Standard)
8	Usability of the Module
	Wirtschaftsingenieurwesen and Wirtschaftsinformatik (Bachelor)
9	Literature Bamberg, G., Baur, F., Krapp, M.: Statistik Fahrmeir L. et al.: Statistik: Der Weg zur Datenanalyse Papula, L.: Mathematik für Ingenieure und Naturwissenschaftler, Band 3
10	Comment

Mod	lule na	me								
	Selec	cted To	pics in	Logic						
Mod no.		Credit Points			3		Duration		Frequency Irregular	
	04-10- 9 CP 0594		270 h		2/U N	1 Seme	ster	irregui	ar 	
	•	of Instru d Englis				son respons . Dr. phil. na				
1	Course	es of the	e Modul	le	•					
	Course no. Course		e name	Workloa		(CP)	Form Teac	_	Contact Hours per Week	
	04-10-0)591-vu	Selected	l Topics in Logic		•		Lecture and Exercise		0
2	Depend		the inst	ructor, this course n higher types, ga						
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in computational logic - are able to extend their knowledge in this field - are able perform supervised research in this field									
4	Requir	ements	for Pa	rticipation						

5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung: Usually the exam is taken in form of an oral exam, except when there are bigger number of potential participants. In this case, the exam can be taken in the form of a written exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature depending on the topic
10	Comment recommended: Mathematics: Master (log)

Mod	Module name												
	Graph Theory												
Module no.		Credit Points Workload		Self	Self-study Duratio		on Frequency		ncy				
04-1 059	10- 5/en		9 CP	270 1	1	270 h	1 Semes	ter	Irregula	r			
Lan Eng	•	of Instru	ıction			con responsible for the Module rer. nat. Kord Eickmeyer							
1	Course	es of the	e Modul	le									
	Course no. Course name					Forn Teac		Contact Hours per					

· 					Week
	04-10-0595-vu	Graph Theory	0	Lecture and Exercise	0
2	Study Conten Graphs, conne structure theor	ctivity, colourability, ex	xtremal graph theo	ry, Ramsey theory, gra	ph
3	connectedness	comes re expected to get a tho re, planarity, colourability ry and obtain the skills	y, extremal graph t	theory, Ramsey theory	and graph
4	Requirements	s for Participation			
5	Standa Fachprüfung: I only a small nu form of an ora communicated	Examination: le Examination (Techning) Usually the exam is take umber of potential part I exam. The decision all t two weeks of the lect	en in form of a wricipants. In this cas	tten test, except when se, the exam can be take e exam is taken and	there are ten in the
6	Requirements Bestehen der F	s on the Award of Cre Fachprüfung	dit Points		
7		Examination: le Examination (Techni :: 100%, Standard)	ical Examination, o	ral / written Examinat	ion,
8	Usability of th	ne Module			
9	Usability of the Literature Diestel: Graph Bollobas: Mod	ne Module Theory, Springer Verlaern Graph Theory, Springer: Graphs on Surfaces	inger Verlag	-University Press	

Mod	dule na	me								
	Geoi	metrv (for Tea	ching Degrees)						
Mod no. 04-1	dule			oints Workload		-study 180 h	Duration 1 Semester		Frequency Every 2. semester	
Lan	Language of Instruction German				son respons					
1	ι	es of the	e Modu	le		1	<u> </u>	- 6-		
			Cours	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0)596-vu	Geomet Degrees	ry (for Teaching)		0		Lectur Exerci		0
3	Study Content Euklidische Geometrie: Geraden, Dreiecke; Kurven; Ausblick in sphärische, hyperbolische oder projektive Geometrie; Konstruktionen in DGS und ihre Beschreibung. Learning Outcomes Die Studierenden kennen und verstehen die elementargeometrischen Grundbegriffe und Methoden und können diese auf typische Fragestellungen anwenden. Sie können geometrische Fragestellungen mit einer DGS bearbeiten.									
4	_			rticipation LaB) und Analysis	1 (fü	ir LaB). Teil	nahme o	hne N	achweis	möglich.
5	 Lineare Algebara (für LaB) und Analysis 1 (für LaB). Teilnahme ohne Nachweis möglich. Form of Examination Final Module Examination: Module Examination (Study Examination, Special Form, Standard) Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung: In der Regel erfolgt die Prüfung durch eine Klausur, bei geringer Teilnehmerzahl gegebenenfalls mündlich. Die Form der Prüfung wird anhand der voraussichtlichen Teilnehmerzahl in den ersten beiden Veranstaltungswochen festgelegt. Studienleistung: In der Regel erfolgreiche Teilnahme am Übungsbetrieg. Eventuelle Abweichungen werden in der ersten Vorlesungswochen bekannt gegeben 									
6	Requir	ements	on the	Award of Credit	Poin	ts				

	Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung
7	 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Standard) Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Lehramt
9	Literature I. Agricola, T. Friedrich: Elementargeometrie, Springer 2015 G.A. Jennings: Modern geometry with applications, Springer 1994
10	Comment

Mod	Module name										
	Introduction to Numerical Analysis (for Teaching Degrees)										
Module no. Cred 04-10- 0597		Credit	Points 5 CP	Workload 150 h		-study 150 h	Duration 1 Semester		Freque Every 2 semest	2.	
Lan	Language of Instruction Person responsible for the Module										
Geri	nan				Prof	Dr. rer. na	t. Jens La	ang			
1	Courses of the Module										
	Course no. Cour		Course	se name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)597-vu		ction to Numerical s (for Teaching Degr	*		Lecture and Exercise		0		
2	error a interpo differen quadra linear s	olation ntiation	of equa ation	tions							

3 Learning Outcomes

Die Studierenden können die grundlegenden elementaren numerischen Verfahren beschreiben, erklären, implementieren und anwenden. Sie sollen die Methoden vergleichen, modifizieren und kombinieren können.

4 Requirements for Participation

empfohlen: Analysis und Lineare Algebra, Einführung in die Programmierung

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Fachprüfung: In der Regel erfolgt die Prüfung durch eine Klausur, bei geringer Teilnehmerzahl gegebenenfalls mündlich. Die Form der Prüfung wird anhand der voraussichtlichen Teilnehmerzahl in den ersten beiden Veranstaltungswochen festgelegt.

Studienleistung: In der Regel erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung;

Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

Lehramt

9 Literature

Deuflhard, Hohmann: Numerische Mathematik I, de Gruyter, 2008 Schwarz, Köckler: Numerische Mathematik; Vieweg und Teubner, 2009 Matlab User Guide

10 | Comment

Mod	lule na	me								
	Matl	nematio	cs of M	achine Learning						
Mod no. 04-1 059	lule	Credit Points 4 CP				- study 120 h	Duration 1 Semester		Freque Every 2 semest	2.
Lan Geri		of Instru	ıction			son respons				
1	Course	es of the	e Modu	le						
	Course no. Course name		e name		Workload	(CP)	Form Teac		Contact Hours per Week	
	04-10-0)598-vu	Mathen Learnin	natics of Machine g		0		Lectur Exerci		0
	Systems of linear equations and linear least squares problems, linear regression, eigenvalue and singular value decomposition, mean component analysis, Bayes stastistics, ridge regression, dimension reduction, low rank approximation, nonlinear least squares and minimization problems, Newton method, nonlinear regression, LASSO, regularization, interpolation and numerical integration, function approximation, radial basis functions, Monte-Carlo methods, networks for regression, convolutional neural networks, training of networks, deep learning									
3	Learning Outcomes On successful completion of this module, students should be able to: 1. Explain fundamental conceptions and concerns of data analysis and machine learning, 2. Describe and apply fundamental algorithms to analyze data and to explain their relations in content and logic, 3. Implement the most important computational methods by means of typical applications and assess their importance and reliability, 4. Obtain advanced mathematical knowledge in their future academic studies and jobs via self-study									
4	_			rticipation mmended						
5		of Exam Iodule I Modul Standa	Examina e Exam		Exai	nination, W	ritten Ex	am, D	uration	45 min,

6	Requirements on the Award of Credit Points Bestehen der Prüfungsleistung
7	Grading Final Module Examination: • Module Examination (Technical Examination, Written Exam, Weight: 100%, Standard)
8	Usability of the Module Bachelor MB compulsory
9	Literature Ethem Alpaydin: Maschinelles Lernen, de Gruyter Studium, 2019; Gilbert Srang: Linear Algebra and Learning from Data, Wellesley Cambridge Press, 2019; Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer, 2008
10	Comment

Mod	dule na	me								
	Lie-G	iroups								
Module no. 04-10- 0599		Credit Points 5 CP		Workload 150 h	J		Duration 1 Semester		Frequency Irregular	
Lan	Language of Instruction German and English					on respons . Dr. rer. nat				
1	Course	es of the	e Modul	le						
	Course no. Cours			e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)382-vu	Lie grou	ıps		0			re and se	3
2	Study Content Differential Calculus on submanifolds, Lie groups as ``differentiable group", matrix groups, Lie algebra of a Lie group, Lie functor, Lie group-exponential function									
3		Learning Outcomes After attending this module								

- students are familiar with the basic definitions of Lie group, Lie algebra, Lie group morphism, Lie functor, adjoint representation, and Lie group exponential function
- have become familiar with some important concrete examples of real and complex matrix groups and are able to handle them
- have gained a first insight into the theory (finite dimensional real) Lie groups and understood how to study such using Lie algebras.

4 Requirements for Participation

Recommended: Algebra (elementary Group Theory)
Basic Knowledge in Topology is helpful but not necessary

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung: Usually the exam is taken in form of an oral exam (30 min), except when there are bigger number of potential participants. In this case, the exam can be taken in a written exam (90 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc.-Math: Vertiefungsbereich M.Sc.-Math: Ergänzungsbereich

9 Literature

Skript,

J. Hilgert, K.H. Neeb: Lie-Gruppen und Lie-Algebren, Vieweg (1991)

10 Comment

Mod	dule na	me								
	Sele	cted To	pics in	Logic						
Mod no. 04-1 060		Credit	Points 9 CP	Workload 270 h		-study 180 h	Duration 1 Semester		Frequency Irregular	
	guage o					on respons Dr. rer. nat			odule	
1	Course	es of the	e Modul	le						
	Course	e no.	Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0	0600-vu	Selected	l Topics in Logic		0		Lectur Exerci		6
2	Study Content selected topics in logic									
	Learning Outcomes Students understand and are able to apply the notions, methods and results treated in the course. They have developed an advanced level of understanding of a specific topic in logic. They are able to extend their knowledge in this field, which allows them to conduct related research under supervision.									
4	_			ticipation ling on topic						
5			ination Examina							
	•	Modul Standa		nation (Technical	Exan	nination, ora	al / writt	ten Exa	aminati	on,
	Fachprüfung: Usually the exam is taken in form of an oral exam (30 min), except when there are bigger number of potential participants. In this case, the exam can be taken in a written exam (90 min). The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	_		on the	Award of Credit	Poin	ts				
7	Gradin	ıg								

	Final Module Examination:									
	 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) 									
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics									
9	Literature									
	depending on topic									
10	Comment									
	recommended: Mathematics: Master (log)									

Mod	lule na	me									
	Selec	ted To	pics in	Stochastics	•						
Mod no. 04-1	.0-	Credit Points 9 CP				- study 270 h	Duration 1 Semester		Frequency Irregular		
Language of Instruction German and English					Person responsible for the Module Prof. Dr. rer. nat. Frank Aurzada						
1	Course no. Course name					Workload	(CP)	Form of Teaching		Contact Hours per Week	
	04-10-0	601-vu	Selected	l Topics in Stochatic	es	0		Lectur Exerci		0	
2	Study Content various possible directions, for example - random graphs and geometric models in probability - Malliavin calculus and stochastic analysis - Levy processes - selected topis in mathematical statistic										
3	Learning Outcomes Students acquire knowledge in the respective topic and are able to self-study further material in a guided fashion										
4	-			rticipation ds on topic, but at	mini	mum probal	oility the	ory			

Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard) Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated by the instructor during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics Literature depends on topic

Module Description

Comment

10

Mod	lule na	me												
	Statistics/Probability Theory													
Mod no. 04-1 060	LO-	Credit	Points 4 CP	Workload	120 h	Self-study 75 h		Duration 1 Semester		Frequency Every 2. semester				
	guage man	of Instru	ıction			Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich								
1	Course	es of the	e Modul	le										
	Course no. Course		e name			Workload	(CP)	Form Teac		Contact Hours per Week				

	04-10-0602-vu	Statistics/Probability Theory	0	Lecture and Exercise	3								
2	Study Content Grundbegriffe der Statistik und Wahrscheinlichkeitstheorie, Regression, multivariate Verteilungen, Schätzverfahren und Konfidenzintervalle, Tests bei Normalverteilungsannahme, robuste Statistik												
3		comes stische Auswertungen vorzune durchzuführen.	hmen, grundlegende	Schätzverfah	ren und								
4	_	for Participation und Mathematik 2 (empfohler	1)										
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Written Exam, Duration 90 min, Standard)												
6	Requirements	on the Award of Credit Poir	nts										
7	Grading Final Module I Modul Standa	e Examination (Technical Exa	mination, Written Ex	am, Weight: 1	00%,								
8	Usability of th	ne Module											
9	Literature Von Finckenste II, Teubner Ve	ein, Lehn, Schellhaas, Wegmar rlag Stuttgart	nn: Arbeitsbuch für Iı	ngenieure									
10	Comment												

Module name													
Scier	ntific Computi	ng (EE)											
Module no. 04-10-	Credit Points 4 CP	Workload 120 h	Self-study 75 h	Duration	Frequency Every 2. semester								

060	3											
	•	of Instru	ıction		ı	son respons						
	man				Prof	Dr. rer. na	t. Stefan	Ulbric	h			
1		es of the										
	Course	e no.	Cours	e name		Workload (CP)			of hing	Contact Hours per Week		
	04-10-0)603-vu	Scientif	ic Computing		0	Lecture and 3 Exercise					
2	Numer Numer	ische Qı	sung lir uadratu	nearer Gleichun rverfahren, Nich rentialgleichung	ntlinear	e Gleichung:	ssysteme	-	_	tproblem		
3	Fähigk	_	rundleg	gende Aufgabens uwenden.	stellung	en geeignet	e numeri	sche V	erfahre	en		
4	Requirements for Participation											
5		of Exam Iodule I										
	•	Modul Standa		ination (Technio	cal Exar	nination, W	ritten Ex	am, Dı	ıration	90 min,		
6	Requir	ements	on the	Award of Cred	lit Poin	ts						
7	Gradi r Final M	ig Iodule E	Examina	ntion:								
	•	Modul Standa		ination (Technio	cal Exar	nination, W	ritten Ex	am, W	eight: 1	100%,		
8		ity of th		ıle EC, B.Sc.CE, B.S	Sc.Inf,							
9			-	n, Schellhaas, V ttgart	Vegman	n: Arbeitsbu	ıch für In	igenie	ure			
10	Comment											

Мо	dule na	me									
Mo no. 04- 060	dule 10-	•		chdidaktische Sc Workload 180 h	•	-study	Duration 1 Semes	on Freque		ency 2.	
	nguage o	of Instru	action		Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
1	Course no. Course name					Workload	(CP)	Form Teac	_	Contact Hours per Week	
	04-00-0044-se Practical training in scho for mathematics 04-10-0604-se Beratung und Reflexion				II	0		Semin		2	
	Beobachtung, Planung und Reflexion von Mathematikunterricht sowie didaktischer und methodischer Konzepte der Unterrichtsgestaltung unter Einbindung fachdidaktischer Literatur; tiefgreifende Auseinandersetzung mit einem fachdidaktischen Schwerpunkt. Die Studierenden führen ihr Portfolio aus den Praxisphasen I und II während der Praktikumszeit fort, nehmen an einem für berufliche Schulen spezifischen Beratungsangebot teil und verfassen einen Praktikumsbericht.										
3	Die Stu analys: Sie kör	Beratungsangebot teil und verfassen einen Praktikumsbericht. Learning Outcomes Die Studierenden sind in der Lage, kriterienbasiert Unterricht zu beobachten, zu analysieren und zu planen und die eigene Durchführung entsprechend zu reflektieren. Sie können auf der Grundlage fachdidaktischer Literatur Unterrichtsentwürfe mit didaktischer und methodischer Analyse verfassen.									
4	Grund	Requirements for Participation Grundlagen des Lehrens und Lernens von Mathematik, Praxisphase I (Teilnahme ohne Nachweis möglich)									
5		Grundlagen des Lehrens und Lernens von Mathematik, Praxisphase I (Teilnahme ohne Nachweis möglich) Form of Examination Final Module Examination:									

Fachprüfung: Sonderform (benoteter Praktikumsbericht)

Studienleistung: Sonderform (Hausübungen, Unterrichtsbesuch mit Reflexion,

	Fortführung des Portfolios aus den Praxisphasen I und II, Teilnahme an einem Beratungsangebot)
6	Requirements on the Award of Credit Points
7	 Grading Final Module Examination: Module Examination (Study Examination, Special Form, Weight: 0%, Standard) Module Examination (Technical Examination, Portfolio, Weight: 100%, Standard)
8	Usability of the Module LaB
9	Literature
10	Comment

Mod	lule na	me										
	Selected Topics in Analysis											
Mod no. 04-1 060	10-	Credit	Points 9 CP	Workload 270 h	Self-study 180 h		Duration 1 Semester		Frequency Irregular			
	guage o				Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber							
1	Courses of the Module											
	Course no. Course name			e name		Workload	(CP)	Form Teac	-	Contact Hours per Week		
	04-10-0	605-vu	Selected	d Topics in Analysis		0		Lectur Exerci		6		
2	Study	Conten	t									
	depending on topic, examples include: - conservation equations - stochastic PDEs											

- geo-physical flows
- free boundary value problems
- chemotaxis
- Besov spaces
- pseudo differential operators

3 Learning Outcomes

Students

- understand and are able to apply the notions, methods and results treated in the course
- develop an advanced level of understanding of a specific topic in analysis
- are able to extend their knowledge in this field
- are able perform supervised research in this field

4 Requirements for Participation

recommended: depending on topic, typically Functional Analysis

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

depending on topic

10 Comment

recommended: Mathematics: Master (ana)

Mod	dule na	me								
	Sele	cted To	pics in	Logic						
Mod no. 04-1	dule		_	Workload 150 h	Self	- study 105 h	Duratio 1 Semes		Freque Irregul	•
		of Instru d Englisl			Person responsible for the Module Prof. Dr. phil. nat. Ulrich Kohlenbach					
1	Course	es of the	Modu	le						
	Course no. Course name					Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-10-0)606-vu	Selected	l Topics in Logic		0		Lectur Exerci	-	3
3	Study Content Depending on the instructor, this course treats e.g. logical aspects of term rewriting, computability theory in higher types, game-theoretic semantics of functional programs etc. Learning Outcomes Students									
	Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of a specific topic in computational logic - are able to extend their knowledge in this field - are able perform supervised research in this field									
4	Requir	ements	for Pa	rticipation						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung: Usually the exam is taken in form of an oral exam, except when there are bigger number of potential participants. In this case, the exam can be taken in the form of a written exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.									
6	Requir	ements	on the	Award of Credit	Poin	ts				

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on the topic
10	Comment recommended: Mathematics: Master (log)

Mod	lule nar	me								
	Disco	ontinuo	ous Gal	erkin Methods (9 CP)				
Mod no. 04-1 060	LO-	Credit	Points 9 CP	Workload 270 h	Self-study 180 h		Duratio 1 Seme		Freque Irregula	•
Lan ; Geri	guage o	of Instru	ıction			son respons f. Dr. rer. na				
1										
	Course no. Course name			e name		Workload	(CP)	Form of Teaching		Contact Hours per Week
	04-10-0	607-vu	Discont (9 CP)	inous Galerkin Meth	ods	0		Lectur Exerci		6
2	Study Content Theory of Discontinuous Galerkin methods for linear elliptic parabolic and hyperbolic PDEs; stability and consistency, a-priori and a-posteriori error estimates, interior penalty, upwinding; implementation of practical problems in e.g. matlabTheory of Discontinuous Galerkin methods for linear elliptic parabolic and hyperbolic PDEs; stability and consistency, a-priori and a-posteriori error estimates, interior penalty, upwinding; implementation of practical problems in e.g. matlab									
3		ts know	paradi;	gms for constructing (linear elliptic, p	_					

	PDEs) and can devise, analyse and implement discretisations of these problems
4	Requirements for Participation recommended: Numerical methods for ordinary differential equations, numerical methods for partial differential equations
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
	Fachprüfung: Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M. Sc. Mathematik, M. Sc. Mathematics
9	Literature D. A. Di Pietro, A. Ern: Mathematical Aspects of Discontinuous Galerkin Methods (Book, Springer) B. Riviere: Discontinuous Galerkin Methods for Solving Elliptic and Parabolic Equations (Book, SIAM)
10	Comment

Module n	Module name											
PDE II. Evolution Equations												
Module												
no.	Credit Points	Workload	Self-study	Duration	Frequency							
04-10-	9 CP	270 h	180 h	1 Semester	Irregular							
0608												

	guage of Instru		Person responsible for the Module							
	man and Englis		Proi	f. Dr. rer. nat. Diete	er Bothe					
1	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week				
	04-10-0608-vu	PDE II. Evolution Equations		0	Lecture and Exercise	6				
2	operator semigroups, characterization of semigroup generators due to Hille-Yoshida, dissipative operators and characterization of semigroup generators due to Lumer-Philipps, conservative operators and regularity of operator semigroups									
3	Learning Outcomes The students know and understand the mathematical concepts, methods and results mentioned under the list of learning content, and are able to apply those. They have a deeper understanding of abstract evolution equations. They are able to expand their knowledge in this area independently and to tackle research questions in this field under guidance. Requirements for Participation Recommended: Funktionalanalyis									
4	_	_								
5	Duration Fachprüfung: It only a small nur form of an ora	Examination: e Examination (Technical on 90 min, Standard) Usually the exam is taken amber of potential participal exam. The decision about during the first two week	in fo pants	rm of a written tes In this case, the e form of the exam	t, except when xam can be tak is taken and	there are ken in the				
6	Requirements Passing the Fac	on the Award of Credit chprüfung	Poin	ts						
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of th	e Module		8 Usability of the Module						

9	Literature
	Engel, Nagel: One-parameter semigroups for linear evolution equations, Springer, New York, 2000. Pazy: Semigroups of linear operators and applications to partial differential equations, Springer
10	Comment

Mod	lule na	me								
Computational Electromagnetics										
Mod no. 04-1 061	lule			Workload 150 h	Self-study 105		Duration 1 Semester		Frequency Irregular	
1	guage o					son respons Dr. Kersten S		the M	odule	
1	Courses of the Module Course no. Course name					Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0611-vu Computational Electromagnetics					0		Lecture and Exercise		3
2	Formul eddy c	urrent n	f proble nodel, M	ms in electromagn Iaxwell equations) kin discretization a	, var	iational forn	nulation		_	
3	Learni Studen	ng Outo ts	comes							
	- undei	stand a	nd are a	able to apply the n	otion	s, methods a	and resu	lts trea	ated in t	the course
		-		level of understandiscretizations	nding	g of the solut	ion theo	ory for	electror	nagnetic
	- are al	ole to ex	tend th	eir knowledge in t	his fi	eld				
	- are al	ole perfo	orm sup	ervised research ir	this	field				
4	Requir	ements	for Pa	rticipation						

	Grundlagen in Numerik, Grundkenntnisse partieller Differentialgleichungen
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc.Mathematik, M.Sc.Mathematics, M.Sc.CE, M.Sc.ETIT, M.Sc.Mechanik, M.Sc.Phys.
9	Literature Monk, Finite Element Methods for Maxwell's Equations, Oxford Scientific Publications Alonso-Rodriguez, Valli, Eddy Current Approximation of Maxwell Equations: Theory, Algorithms and Applications, Springer, Braess, Finite Elements, Springer
10	Comment

Mod	Module name											
Einführung in die Numerische Mathematik und Analysis in der Schule												
Module no. 04-10- 0612		Credit	Points 8 CP	Workload	240 h		study 210 h		Duration 1 Semester		Frequency Every 2. semester	
	guage (man	of Instru	ıction			Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
1	Course	es of the	e Modul	le								
	Course no. Course name							Form of Teaching		Contact Hours per Week		

04-00-0159-se	Seminar for subject-specific didactics: Analysis in schools	0	Seminar	2
04-10-0597-vu	Introduction to Numerical Analysis (for Teaching Degrees)	0	Lecture and Exercise	0

2 Study Content

Fehleranalyse, Interpolation, Differentiation, Quadratur, Lineare Gleichungssysteme, lineare Ausgleichsrechnung, nichtlineare Gleichungen.

Funktionspropädeutik, Funktionsuntersuchungen, Lokale Änderungsrate und Grenzwertbegriff, Riemannscher Integralbegriff, Anwendungen der Infinitesimalrechnung in der Schule, Fehlvorstellungen von Schüer*innen; Oberstufencurriculum, Unterrichtsgestaltung, Technologieeinsatz

3 Learning Outcomes

Die Studierenden

- können die grundlegenden elementaren numerischen Verfahren beschreiben, erklären und anwenden.
- können die Methoden vergleichen, modifizieren und kombinieren.
- erlangen fachliche Sicherheit in besonders schulrelevanten Aspekten der Analysis und
- können verschiedene Zugänge und Schwerpunktsetzungen gegeneinander abwägen.
- beherrschen Darstellungen und Konzepte, um Themengebiete der Analysis in der Schule zu veranschaulichen - auch mit Technologieeinsatz
- praktizieren in den Übungen zahlreiche Beispiele für intelligentes Üben, Diagnose und Förderung.

4 Requirements for Participation

Analysis, Lineare Algebra, Grundlagen des Lehrens und Lernens von Mathematik (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Homework, Worksheets, Standard)
- Module Examination (Technical Examination, Special Form, Duration 45 min, Standard)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)

Studienleistung: Sonderform (In der Vorlesung in der Regel eine erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben. Im Seminar in der Regel aktive Mitarbeit in den Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen

oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung;

Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0159-se fachdidaktisches seminar: analysis in der schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z.B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Homework, Worksheets, Weight: 0%, Standard)
- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

Deuflhard, Hohmann: Numerische Mathematik I, de Gruyter, 2008

Schwarz, Köckler: Numerische Mathematik; Vieweg und Teubner, 2009

Büchter, A., Henn, H.-W.: Elementare Analysis: Von der Anschauung zur Theorie. Spektrum 2010.

Greefrath, G., Oldenburg, R., Siller, H. S., Ulm, V., und Weigand, H. G. Didaktik der Analysis. Wiesbaden: Springer-Verlag 2016

Schuppar, B, und Humenberger, H: Elementare Numerik für die Sekundarstufe. Springer 2015.

Tietze, U.-P., Klika, M., Wolpers, H.-H.: Mathematikunterricht in der SII, Bd. 1,

Fachdidaktische Grundfragen, Didaktik der Analysis. Vieweg 2000,

Gängige Schulbücher

10 Comment

Mod	lule na	me								
	Prob	lem so	lving							
Mod no. 04-1 0613	lule .0-	Credit Points 3 CP		Workload 90 h	Self-study 30 I	tudy Durati 30 h 1 Seme		Freque Every 2 semeste	2.	
	Language of Instruction German				Person responder Prof. Dr. phil.					
1	Course	s of the	e Modul	le						
			e name	Workload	Workload (CP)		n of hing	Contact Hours per Week		
	04-00-0	043-pj	Problem	n Solving	0		Projec	:t	4	
3	- Begrin Problem - Überh - Lösem - Anfor sowie I - Entwin mather - Erarb Knobel - Gewin	nlösen lelick über von Proderunge Reflexion der von Proderunge Reflexion der von Proderung vettbeverber von Proderung und vettbeverber vettbevet vettbeverber vettbevet vettbeverber vettbevet vettbeverber vettbeverber vettbeverber vettbeverber vettbeverbeverber vettbeverber vettbeverbeverber vettbeverber vettbevettbeverber vettbeverber vettbev	erschiedernen er einscl eblemau en an ur n entspr comes von Har e Proble und eige verbs, ei	lene Vorstellunger nlägige Forschung ufgaben und Reflec nterrichtsgeeignete rechender Aufgabe ndlungskompetenz mlösungskompete ene Erprobung eine iner Heurismensch	sergebnisse mit xion von Heuris e Problemlöseau en z zur Planung vonz erworben weites Konzeptes zunulung o.ä.	Unterrichtiken fgaben u on Mathererden kan m Proble	ntsbezu nd eige matiku matiku mlösen	nterricht	t, in dem z.B. eines	
4	Grundl	agen de	s Lehre:	rticipation ns und Lernens vo nweis möglich)	n Mathematik,	Praxissen	nester			
5		Iodule I Modul		ition: ination (Study Exa	•	-				
	•	Modul	e Exami	ination (Technical	Examination, F	Iomewor	k Assig	nment,	Standard)	

	Fachprüfung: Hausarbeit							
	Studienleistung: Sonderform (in der Regel erfolgreiche Teilnahme an den Projektveranstaltungen und Führen eines Portfolios)							
6	Requirements on the Award of Credit Points Bestehen der Fachprüfung, Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung							
7	Grading Final Module Examination:							
	 Module Examination (Study Examination, Portfolio, Weight: 0%, Passed / Not Passed) 							
	Module Examination (Technical Examination, Homework Assignment, Weight: 100%, Standard)							
8	Usability of the Module							
	Mathematik: Lehramt							
9	Literature							
10	Comment							

Mod	Module name											
Application-Oriented Teaching and Learning of Mathematics												
Module no. 04-10- 0614		Credit Points 3 CP			90 h	Self-study 30 h		Duration 1 Semester		Frequency Every 2. semester		
	Language of Instruction German Courses of the Module					Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
	Course	e no.	Course	e name			Workload (CF		Form of Teaching		Contact Hours per Week	
	04-00-0	0113-pj Subject-specific project: Application-oriented mathematical lessons				0		Projec	t	4		

2 Study Content

Begriff und verschiedene Konzeptionen eines anwendungsorientierten Mathematikunterrichts;

deskriptives und normatives Modellieren,

Anforderungen an Modellierungsaufgaben und eigene Begutachtungen oder Konstruktionen solcher Aufgaben;

Vertiefte Betrachtung der Kompetenz des mathematischen Modellierens: eigene Modellierungserfahrungen und entsprechende Reflexion oder Betreuung der Modellierungswoche mit Schüler*innen

3 Learning Outcomes

4 Requirements for Participation

Grundlagen des Lehrens und Lernens von Mathematik, Praxissemester (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Portfolio, Passed / Not Passed)
- Module Examination (Technical Examination, Homework Assignment, Standard)

Fachprüfung: Hausarbeit

Studienleistung: Sonderform (in der Regel erfolgreiche Teilnahme an den Projektveranstaltungen und Führen eines Portfolios)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung, Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Portfolio, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Homework Assignment, Weight: 100%, Standard)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

ISTRON-Materialien Bd. 1 - 14

Greefrath, G. (2018). Anwendungen und Modellieren im Mathematikunterricht. Berlin,

Heidelberg: Springer Berlin Heidelberg.

Hinrichs, G. (2008). Modellierung im Mathematikunterricht. Spektrum, Akad. Verlag.

Maaß, K. (2007). Mathematisches Modellieren: Aufgaben für die Sekundarstufe I. Cornelsen Scriptor.

Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.

10 Comment

Mod	Module name										
	Exercise Practical online										
no. 04-1	Module no. C. 04-10- 0615		Credit Points Workload 3 CP 90			E-study 60 h	Duration 1 Semester		Frequency Every 2. semester		
	guage o	of Instru	uction			son respons . Dr. phil. na					
1	Course	es of the	e Modu	le		1				_	
	Course no. Cours		Course	e name		Workload (C		Form Teac		Contact Hours per Week	
	04-10-0	04-10-0615-pj Fachdidaktisches Projekt: Aufgabenpraktikum online				0 Proj. Sem				2	
2	Fachma Mather Wirtsch	matikun naftsma	tische Vo terricht themati	ertiefung und dida , Auswahl aus Tei k, Optimierung, G graphie, stochasti	lmod raph	ulen zu Knol entheorie, B	oelaufga	ben, S	piralen,	für den	
3	Learni	ng Outo	comes								
	-Fähigl Lösung -Handl Mather -Erfahr	keiten ir gswegen ungswis matik. rungen i	aus verssen zur	erben von Mathematika schiedenen schuli Theorie des Arbe alen Lernumgebu staltung guter Erk	releva itens ngen	inten Theme mit Aufgabe und Feedba	nfelderr n beim I cktechni	n; Lehren iken,	und Ler	rnen von	

4 Requirements for Participation

Grundlagen des Lehrens und Lernens von Mathematik, Praxissemester (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Homework Assignment, Standard)
- Module Examination (Study Examination, Portfolio, Passed / Not Passed)

Fachprüfung: Hausarbeit

Studienleistung: Sonderform (in der Regel erfolgreiche Teilnahme an den Projektveranstaltungen und Führen eines Portfolios)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung, Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Homework Assignment, Weight: 100%, Standard)
- Module Examination (Study Examination, Portfolio, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

Wagner, A. amp; Wörn, C. (2011). Erklären lernen - Mathematik verstehen. Ein Praxisbuch mit Lernangeboten. Seelze: Klett Kallmeyer.

Kiel, E.; Meyer, M.; Müller-Hill, E. (2015): Erklären. Was? Wie? Warum? - In: PM: Praxis der Mathematik in der Schule, 57 (2015) 64, 2-9.

MOODLE-Kurs online mit Skript

10 Comment

Module Description

Module name

Mathematical Statistics

no. 04-1	Module no. (04-10-0616/en		Points 9 CP	Workload 270 h	Self-study h 180		Duratio 1 Seme		Frequency Every 3. semester	
Lan Engl		of Instru	action			son respons . Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no.		Course name			Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)616-vu	Mathen	natical Statistics		0		Lectur Exerci		6
2	Study Content Estimation of distributations, VC theory, density estimation, point estimates, statistical tests, confidence intervals. Possible societal implications will be addressed in the lecture.									
3	Learning Outcomes The students know and understand the above mentioned concepts, methods and results, and are able to apply them. They have a deep unterstanding of Mathematical Statistics and are able to learn new knowledge in this field by themselves. Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly.									
4	-			rticipation oility theory						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)									
	Usually the exam is taken in form of a written test, except when there are only a smanumber of potential participants. In this case, the exam can be taken in the form of a oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of studer taking the exam.									
6	Requirements on the Award of Credit Points Passing the Fachprüfung;									

7	Grading Final Module Examination:								
	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)								
8	Usability of the Module								
	M. Sc. Mathematics, Mathematics in Data Science								
9	Literature								
	Lehmann, Romano: Testing Statistical Hypotheses.								
	Devroye, Lugosi: Combinatorial methods in density estimation								
10	Comment								

Module name										
Statistical theory for Deep Learning										
Module no. 04-10- 0617/en		Credit Points 9 CP		Workload 270 h		- study 180 h	Duration 1 Semester		Frequency Every 3. semester	
						son respons . Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no.		Course name			Workload (CP)		Teaching H		Contact Hours per Week
	04-10-0)617-vu	Statistic Learnin	eal theory for Deep		0		Lecture and Exercise		6
2	Study Content types of neural networks, nonparametric regression and image classification, gradient descent, approximation results for feed forward neural networks, rate of convergence for least squares neural network estimates, analysis of neural networks learned by gradient descent Possible societal implications will be addressed in the lecture									
3		ng Outo udents l		nd understand the	abov	e mentioned	l concep	ts, met	thods a	nd results,

and are able to apply them. They have a deep unterstanding of Deep Learning and are able to learn) new knowledge in this field by themselves.

Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly.

4 Requirements for Participation

recommended: Probability theory

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)

Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung;

7 Grading

Final Module Examination:

• Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

M. Sc. Mathematics, Mathematics in Data Science

9 Literature

Goodfellow, Bengio, Courville: Deep Learning.

Györfi, Kohler, Krzyzak, Walk: A distribution - free theory of nonparametric regression

10 Comment

Module name											
Deep Learning Lab											
Module no.	Credit Points		_		Frequency						
04-10-	5 CP	150 h	105 h	1 Semester	Irregular						

061	8/en											
Lan Eng	guage of Instru	uction	,		Person responsible for the Module Prof. Dr. Yann Disser							
1	Courses of the	e Modu	le									
	Course no.	Cours	Course name		Workload	(CP)	Form of Teaching		Contact Hours per Week			
	04-10-0618-vu	Deep Le	earning Lab		0		Lectur Exerci		3			
2	Study Content introduction to deep learning, mathematical foundations, Keras and TensorFlow, classification, convolutional neural nets, adversarial deep learning, text generation Possible societal implications will be addressed in the lecture											
3	Learning Outcomes The students know and understand the concepts and methods taught in the course and can apply them. They have a thorough understanding of the formal foundations of deep learning. They are able to independently expand their knowledge of the field and pursue supervised research projects. Students are able to contextualize subject matter within the social context, critically assess the consequences, and act ethically and responsibly accordingly.											
4	Requirements for Participation Recommended: Algorithmic Discrete Mathematics Einführung in die Optimierung (Introduction to optimization) programming expertise (ideally Python)											
5	Form of Exam Final Module I											
	ModulStudienleistun		ination (Study Exentation	xamina	ition, Paper,	Passed	/ Not	Passed)				
6	Requirements on the Award of Credit Points Passing Studienleistung											
7	Grading Final Module Examination: • Module Examination (Study Examination, Paper, Weight: 0%, Passed / Not Passed)											
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science											

9	Literature Deep Learning with Python (2nd edition) - François Chollet	
10	Comment	

Mod	dule na	me									
	Effic	ient Me	thods '	for Data Assimila	ation	1					
Module no. 04-10- 0619/en		Credit Points 5 CP		Workload 150 h	Self	- study 105 h	Duratio 1 Seme	-		•	
Lan Eng	•	of Instru	ıction			on respons . Dr. rer. nat					
1	Course	es of the	e Modul	le	1						
			Cours	se name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-10-0)619-vu	Efficien Assimila	t Methods for Data		0		Lectur Exerci	3		
	Monte- Kalmai model	-Carlo m n filter a reductio	nethod, and Ense on meth	of Data Assimilativariational approa Variational approa emble Kalman filte ods; above methods	ches	(4DVar), Se	equential	l appro	oaches ai	nd 3DVar,	
3	Learning Outcomes The students know the most important methods of variational and sequential data assimilation. They understand their properties and numerical challenges arising when these methods are used in practise. They can choose appropriate data assimilation methods for specific applications and they can implement and analyse these methods.										
4	Requirements for Participation Recommended: Einführung in die Stochastik (Introduction to Stochastics), Gewöhnliche Differentialgleichungen (Ordinary Differential Equations), Einführung in die Numerische Mathematik (Introduction to Numerical Analysis)										
5	_	of Exam Iodule I									

• Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

M. Sc. Mathematics, Mathemaics in Data Science

9 Literature

Kody Law, Andrew Stuart, Konstantinos Zygalakis; Data Assimilation: A mathematical introduction, Springer, 2015

Mark Asch, Marc Bocquet, Maelle Nodet; Data Assimilation: Methods, Algorithms and Applications, SIAM 2016

10 Comment

Mod	Module name											
	Numerics of PDEs with Uncertain Data											
Module no. 04-10- 0620/en		Credit	Points 9 CP	Workload	270 h		• study 180 h	Duration 1 Semester		Frequency Irregular		
	Language of Instruction English					Person responsible for the Module Prof. Dr. rer. nat. Jens Lang						
1	Course	es of the	Modul	le					ı			
	Course no		Cours	e name			Workload (CP) Form		n of hing	Contact Hours per Week		

	04-10-0620-vu Numerics of PDEs with Uncertain Data	0	Lecture and Exercise	6					
2	Study Content Examples of PDEs, weak solutions of elliptic finite element method, error estimates, strong formulations of elliptic PDEs with un Monte Carlo finite elements, multi-level Monte Carlo finite elements, weak formulations of elliptic PDEs with unce Karhunen-Loeve expansion, weak solutions of parabolic PDEs, Method of Lines or Rothe Meelements, implementation of the above methods	certain data, ertain data, stochastic	c Galerkin met	hod,					
3	Learning Outcomes Students will be able to describe, explain and apply the main design principles of numerical solution methods for linear elliptic and parabolic partial differential equations with deterministic as well as uncertain data. They will be able to analyze, evaluate, implement and compare the methods.								
4	Requirements for Participation Recommended: Introduction to Numerical A Differential Equations	nalysis, Numerical M	ethods for Oro	dinary					
5	Form of Examination Final Module Examination: • Module Examination (Technical Exa Duration 90 min, Standard) Usually the exam is taken in form of a writte number of potential participants. In this case oral exam. The decision about the form of the during the first two weeks of the lecture, bas taking the exam.	n test, except when t e, the exam can be tal ne exam is taken and	here are only ken in the forr communicated	a small n of an d					
6	Requirements on the Award of Credit Poir Passing Fachprüfung	nts							
7	Grading Final Module Examination: • Module Examination (Technical Exa Weight: 100%, Standard)	mination, oral / writ	ten Examinati	on,					
8	Usability of the Module								

	M. Sc. Mathematics, Mathemaics in Data Science
9	Literature S. Brenner, R. Scott: Mathematical Theory of Finite Element Methods, Texts in Applied Mathematics, Vol. 15, Springer, 2008
	S. Larsson, V. Thomée: Partial Differential Equations with Numerical Methods. Texts in Applied Mathematics, Vol. 45, Springer 2003.
	G. J. Lord, C. E. Powell, and T. Shardlow. An Introduction to Computational Stochastic PDEs. Cambridge University Press, 2014.
10	Comment

Mod	lule na	me								
	Scala	able Lin	ear So	lvers for Data Sc	ienc	е				
Module no. Cred 04-10- 0621/en		Credit	Points 5 CP			-study Duration 105 h 1 Semes				•
Lan	guage (of Instru	ıction			son respons			odule	
Eng	lish				Prof	Dr. rer. na	t. Jens La	ang		
1	Course	es of the	e Modul	le						
	Course no.		Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-10-0)621-vu	Scalable Science	e Linear Solvers for l	Data	0		Lecture and Exercise		3
2	Science Exercise Study Content Preconditioning of linear systems of equations, conjugate gradient method, linear iterative methods, preconditioning with incomplete decompositions, subspace correction methods, hierarchical bases and multigrid methods, bandwidth minimisation									
3	Studen design	princip	e able t les of sc	o describe, explair alable linear solve nd compare the m	rs for	Data Science		will be	e able to	o analyze,

4	Requirements for Participation Recommended: Introduction to Numerical Analysis
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)
	Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science
9	Literature Wolfgang Hackbusch, Iterative Solution of Large Sparse Systems of Equations, 2nd ed. 2016, Applied Mathematical Sciences Vol. 95, Springer International Publishing, 2016
10	Comment

Mod	Module name										
Data Assimilation for Fluid Dynamics											
Mod no.	lule	Credit Points	Workload	Self-study	Duration	Frequency					
04-1 062	10- 2/en	5 CP	150 h	105 h	1 Semester	Irregular					
Lan	guage	of Instruction		Person responsible for the Module							
English			Prof. Dr. rer. nat. Moritz Egert								
1	Courses of the Module										

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week						
	04-10-0622-vu	Data Assimilation for Fluid Dynamics	0	Lecture and Exercise	3						
2	Study Content Dynamical systems and control theory, feedback control (nudging approach), observational measurements, asymptotic stability, reference solutions, reconstruction of solutions without initial data. Classical data assimilation algorithms (Kalman filter, AOT), resolution of spatial mesh, nodal interpolation. Fundamental equations in fluid dynamics, Boussinesq approximation.										
3	Students unde course. They d	Learning Outcomes Students understand and are able to apply the notions, methods and results treated in the course. They develop an advanced level of understanding of partial differential equations through the methodology of data assimilation and are able to extend their knowledge in this field.									
4	_	s for Participation l: Functional Analysis, Partial	Differential Equation	ns I							
5	Form of Exam Final Module I										
	Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)										
Usually the exam is taken in form of a written test, except when there are on number of potential participants. In this case, the exam can be taken in the oral exam. The decision about the form of the exam is taken and communiduring the first two weeks of the lecture, based on the prospective number taking the exam.											
6	Requirements Passing Fachpi	s on the Award of Credit Porufung	ints								
7		Examination: le Examination (Technical Ex :: 100%, Standard)	amination, oral / wri	itten Examinati	ion,						
	- 6										

8

Usability of the Module

	M. Sc. Mathematics, Mathematics in Data Science
9	Literature M. Tucsnak, G. Weiss: Observation and Control for Operator Semigroups (Springer) TP. Tsai: Lectures on Navier-Stokes Equations (AMS) S. Reich, C. Cotter: Probabilistic Forecasting and Bayesian Data Assimilation (Cambrige University Press)
10	Comment

Mod	lule na	me								
	First	order ı	nethod	ls for optimization	on in	data analy	/tics			
no. 04-1	Module no. Cre		Points 5 CP	Workload 150 h	Self	- study 150 h	Duration 1 Semester		Frequency Irregular	
	0	of Instru	ıction			son respons . Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course no. Cour		Cours	e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-10-0)623-vu		ler methods for ation in data analyti	cs			Lectur Exerci		0
2	First-or applica with re algoriti	itions in elatively hms for sign and	thods ar data ar simple challen	re a highly active r nalytics. They ofter iteration schemes ging large scale pr of first-order prox	n com and p obler	nbine primal provide very ns. This cou	-dual de efficient rse gives	compo struct an int	osition a ture-exp croduction	pproaches loiting on into
3	Learning Outcomes The students are able to apply and investigate important classes of first-order optimization methods, in particular proximal point and primal-dual methods. They are prepared for studying scientific developments and applications in this field independently.									
4	_			rticipation uction to Optimiza	ation	; Nonlinear	Optimiza	ation		

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)

Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

M. Sc. Mathematics, Mathematics in Data Science

9 Literature

Stephen Boyd, Neal Parikh, Eric Chu, Borja Peleato, Jonathan Eckstein: Distributed Optimization and Statistical Learning via the Alternating Direction Method of Multipliers, Foundations and Trends in Machine Learning Vol. 3, No. 1 (2010), 1–122. Antonin Chambolle, Thomas Pock: A First-Order Primal-Dual Algorithm for Convex Problems with Applications to Imaging, Journal of Mathematical Imaging and Vision, Vol. 40, No. 1 (2011), 120-145.

Christian Clason, Tuomo Valkonen: Intoduction to Nonsmooth Analysis, arXiv:2001.00216v3, https://doi.org/10.48550/arXiv.2001.00216

10 Comment

Module na	Module name											
Opti	Optimization Methods for Maschine Learning											
Module no.	Credit Points	Workload	Self-study	Duration	Frequency							
04-10- 0624/en	5 CP	150 h	105 h	1 Semester	Every 2. semester							
Language	of Instruction		Person responsible for the Module									

Eng	glish		Prof. Dr. rer. nat. Marc Pfetsch								
1	Courses of the	e Module									
	Course no.	Course name		Workload (CP) Form of Teaching							
	04-10-0624-vu	Optimization Methods for Maschine Learning		0	Lecture and Exercise	3					
2	Foundations of	Study Content Foundations of Maschine learning, Classification (Support Vector Maschines), Matrix Completion, Sparse Regression, Lasso, Neural Networks (Deep Learning)									
3	Learning Outcomes After taking the course, the students have insight into maschine learning. In particular, they know which mathematical optimization methods can be applied in this context and know their properties.										
4	_	s for Participation l: Introduction to Optimiza	ation	, Discrete Optimiza	tion or Nonlin	ear					
5	Final Module I Modul Duration Usually the examumber of potoral exam. The	 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard) Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 									
6	Requirements Passing Fachpu	on the Award of Credit	Poin	ts							
7	• Modul	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of the M.Sc. Mathem	ne Module atics, Mathematics in Data	a Scie	ence							
9	Mitchell: Mach	ani, Friedman: The Eleme nine Learning. Mcgraw-Hil ine Learning: A Probabilis	ll 199	7		000					

	Sra,Nowozin, Wright: Optimization for Machine Learning, MIT Press, 2012 Miroslav Kubat: An Introduction to Machine Learning.Springer, 2015.
10	Comment

Mod	lule na	me								
	Opti	mizatio	n Metl	hods in Data Scie	ence					
Mod no. 04-1 062.		Credit	Points 5 CP			Self-study 105 h		on ster	Frequency Every 2. semester	
Lan Engl	_	of Instru	action			on respons Dr. rer. na				
1	Course	es of the	e Modu	le						
			Cours	e name		Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-10-0)625-vu	Optimiz Science	ation Methods in Da	ata	0		Lectur Exerci		3
2	data pı	-	sing, (s	parse) principal co generative and adv	-	•		•		
3	Learni	ng Outo	comes							
4	-	mended		rticipation luction to Optimiza	ation	; Discrete O	ptimizati	ion or	Nonline	ar
5		of Exam Iodule I								
	Module Examination (Technical Examination, oral / written Examination, Duration 60 min, Standard)									
	numbe	r of pote	ential pa	ken in form of a warticipants. In this on about the form	case,	the exam c	an be tal	ken in	the form	n of an

	the first two weeks of the lecture, based on the prospective number of students taking the exam
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science
9	Literature Hastie, Tibshirani, Friedman: The Elements of Statistical Learning, Springer 2000 Mitchell: Machine Learning. Mcgraw-Hill 1997 Murphy: Machine Learning: A Probabilistic Perspective, MIT Press 2012 Sra,Nowozin, Wright: Optimization for Machine Learning, MIT Press, 2012 Miroslav Kubat: An Introduction to Machine Learning. Springer, 2015.
10	Comment

Mod	Module name									
	Parti	al Diffe	rential	Equations I						
Module		Credit	Points 9 CP Workload 270 h			-study 180 h	Duration 1 Semester		Frequency Every 2. semester	
Language of InstructionPerson responsible for the ModuleEnglishProf. Dr. rer. nat. Matthias Hieber										
1	Course	es of the	e Modu	le		ı				Ī
	Teaching Hour per					Contact Hours per Week				
04-10-0626-vu Partial Differential Equations I 0 Lecture and Exercise						6				
2										

	Sobolev spaces, Galerkin methods, fixed-point methods for non-linear elliptic and parabolic equations, theory of weak solutions for equations in fluid mechanics
3	Learning Outcomes Students understand and are able to apply the notions, methods and results treated in the course. They develop an advanced level of understanding of partial differential equations and are able to extend their knowledge in this field.
4	Requirements for Participation Recommended: Functional Analysis
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Duration 90 min, Standard)
	Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science
9	Literature L.C. Evans: Partial Differential Equations (AMS) D. Gilbarg, N.S. Trudinger: Elliptic Partial Differential Equations of Second Order (Springer) M. Renardy, R.C. Rogers: An Introduction to Partial Differential Equations (Springer)
10	Comment

Mod	dule na	me								
	Mac	hine Le	arning	for Fluid Dynam	ics					
no. 04-1	Module no. Credit Points Work 04-10- 5 CP 0627/en		Workload 150 h		- study 150 h	Duration 1 Semester		Frequency Irregular		
Lan Engl		of Instru	action			son respons f. Dr. rer. na				
1	Course	es of the	e Modu	le	•					
	Course	e no.	Cours	e name		Workload	(CP)	Forn Teac	n of hing	Contact Hours per Week
	04-10-0)627-vu	Machin Dynami	e Learning for Fluid cs		0		Lectui Exerci		0
	Navier-Stokes Equations (NSE) for two-phase incompressible flows with mass transfer. The unstructured Finite Volume method. The ALE and VOF methods for simulating incompressible two-phase flows. Deep Learning (DL) for general function approximation. Deep Learning for segregated solution algorithms for NSE. Physics-informed Machine Learning (Pi-ML) - a collocation method with Artificial Neural Networks. Designing Pi-ML models for segregated solution algorithms for NSE, and curvature approximation for two-phase flows.									
3										
4	Requirements for Participation Recommended: Partial Differential Equations									
5			Examina e Exam		Exai	mination, or	al / writi	ten Ex	aminati	on,

	Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science
9	Literature Moukalled, F., Mangani, L., amp; Darwish, M. (2016). The finite volume method. In The finite volume method in computational fluid dynamics (pp. 103-135). Springer, Cham. Maric, Tomislav, Jens Hopken, and Kyle Mooney. "The OpenFOAM technology primer." (2014). Karniadakis, G. E., Kevrekidis, I. G., Lu, L., Perdikaris, P., Wang, S., amp; Yang, L. (2021). Physics-informed machine learning. Nature Reviews Physics, 3(6), 422-440. Physics-Based ML in OpenFOAM - OpenFOAM Workshop Training: https://youtu.be/uKo3RD3yYrU?list=PLwSEyKg12dVYbpC2wy_RT2
10	Comment

Mod	odule name										
	Representation Theory										
Module no.Credit PointsWorkload04-10- 0628/en5 CP150 h					150 h		study 105 h	Duratio 1 Semes		Frequer Irregula	•
Lan Engl		of Instru	ıction				on respons Dr. rer. nat				
1 Courses of the Module											
	Course	e no.	Course	e name			Workload	(CP)	Form	n of	Contact

				Teaching	Hours per Week	
	04-10-0378-vu	Representation Theory	0	Lecture and Exercise	3	
2	reducibility, M product, wedg of the symmet	tesentations of finite groups, irresentations of finite groups, irreschke's theorem, Schur's lember e product, character theory, gric group, arbitrary ground fies, restriction and induction, mo	ma, tensor product, s roup algebra, represe ld, division algebras,	symmetric entations		
3	groups over th	comes re familiar with the basic resu e the complex numbers. They theoretic problems.	_			
4	_	for Participation , Algebra, Einführung in die A	lgebra			
5			mination, oral / writ	ten Examinati	on,	
6	Requirements	on the Award of Credit Poir	nts			
7		Examination: e Examination (Technical Exa :: 100%, Standard)	mination, oral / writ	ten Examinati	on,	
8	Usability of the Module M.ScMath: Vertiefungsbereich M.ScMath: Ergänzungsbereich					
9		oresentation theory, lear Representations of Finite	Groups.			
10	Comment					

Mod	lule na	me								
	Math	nematio	cs in Co	ontext						
Mod no. 04-1 0023		Credit	Points 5 CP	Workload 150 h	Self	- study 105 h	Duration 1 Semester Frequency Every 4. semester		4.	
Language of InstructionPerson responsible for the InformationGermanProf. Dr. rer. nat. Burkhard K										
1		es of the	e Modu	le	1	., 21, 101, 110.	.,			
	Course			e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-11-0	0023-vu	Mathen	natics in Context		0		Lectur Exerci		3
	Study Content Selected chapters from mathematics in their historical context. In particular -Outline of the history of mathematics; -Numbers from antiquity to modern times; -Irrational numbers, Fibonacci numbers, continued fractions; -Infinity from Zenon to Cantor; -Infinitely small quantities, measure theory, and non-standard analysis; -School mathematics versus university mathematics									
3	Based of give an role of profess	accoun mathen ional er	us conc t of ma natics in	rete mathematical thematics in its int different contexts ent as well as in th	eract	tions with cu l to represen	ılture an	d socie	ety, to a	ssess the
4	-			rticipation is and Linear Alge	bra					
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral exams in small groups, as well as successful participation in the exercise classes where appropriate.									
6	-	ements g the Stu		Award of Credit	Poin	ts				

7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module B.Sc. Mathematik
9	Literature Victor Katz: A History of Mathematics. Harper Collins, 1993. C. Boyer: A History of Mathematics. John Wiley, 1968ff. C. C. Gillispie: Dictionary of Scientific Biography. Charles Scribner's Sons, 1970 - 1991. P. J. Davies, R. Hersh: Erfahrung Mathematik. Birkhäuser, 1994. M. Kline: Mathematical Thought from Ancient to Modern Times. Oxford University Press, 1972. H. Wußing: 6000 Jahre Mathematik. Springer, 2008.
10	Comment recommended: Mathematics: Bachelor year 2

Mod	lule na	me								
	Торс	ology								
Module no. 04-11- 0031/de		Credit Points 5 CP		Workload 150 h			Duration 1 Semester		Frequency Irregular	
-	guage (of Instru	ıction	I		son respons Dr. rer. nat				
1	Course	es of the	e Modu	le						
	Course	e no.	Cours	e name		Workload (CP)		P) Form of Teaching		Contact Hours per Week
	04-00-0	0020-vu	Topolog	gy		0		Lecture and Exercise		3
2	Study Content separation axioms, compactness, function spaces, connectedness, fundamental group and covering maps and spaces									
3	The stu		ndersta	nd and are able to ve a basic underst		•				

	recognise them in various fields of mathematics.
4	Requirements for Participation recommended: Analysis, Introduction to Algebra
5	 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam
	is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Munkres: Topology, Prentice Hall Bredon: Topology and Geometry, Springer Ossa: Topologie, Vieweg Hatcher: Algebraic Topology, Cambridge University Press Dugundji: Topology, McGraw-Hill Kelley: General Topology, Ishi Press
10	Comment recommended: Mathematics: Bachelor year 3 (alg)

Module na	Module name									
Topology										
Module no. 04-11-	Credit Points 5 CP	Workload 150 h	•		Frequency Irregular					

003	1/en										
Lan Eng	guage of Instru	uction			son respons . Dr. rer. na						
1	Courses of the	e Modu	le	•							
	Course no.	Cours	e name	Workload (CP)			Form of Teaching		Contact Hours per Week		
	04-00-0020-vu	Topolog	gy		0		Lectur Exerci		3		
2	Study Content separation axio covering maps	oms, co	mpactness, functic	n spa	aces, connec	tedness,	funda	mental ફ	group and		
3	Learning Outcomes The students understand and are able to apply the notions, methods and results treated in the course. They have a basic understanding of topological concepts and are able to recognise them in various fields of mathematics.										
4	Requirements for Participation recommended: Analysis, Introduction to Algebra										
5	Form of Exam Final Module I										
	• Modul Standa		ination (Technical	Exar	nination, or	al / writ	ten Exa	aminatio	on,		
	only a small nu form of an ora communicated	umber of l exam. l t two w	the exam is taken of potential particip The decision abou eeks of the lecture	pants it the	. In this case form of the	e, the exa exam is	am can taken	i be take and	en in the		
6	Requirements Passing the Fac		Award of Credit	Poin	ts						
7		e Exam	ntion: ination (Technical tandard)	Exai	nination, or	al / writt	ten Exa	aminatic	on,		
8	Usability of the B.Sc. Mathema		a le 2018), M.Sc Matl	hema	tik (PO 2018	8), M.Sc	. Math	ematics			

Literature

Munkres: Topology, Prentice Hall Bredon: Topology and Geometry, Springer

Ossa: Topologie, Vieweg

Hatcher: Algebraic Topology, Cambridge University Press

Dugundji: Topology, McGraw-Hill Kelley: General Topology, Ishi Press

10 Comment

recommended: Mathematics: Bachelor year 3 (alg)

Mod	lule na	me								
	Disci	ete Ma	thema	tics						
Mod no. 04-1		Credit	Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Seme		Freque Irregul	•
	4/de			2, 0 11		10011	1 ocme		1110841	
Lan g Geri		of Instru	action			son respons . Dr. rer. na				
1	Course	es of the	e Modu	le		T				<u> </u>
	Course no. Course name					Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0137-vu Discrete Mathematics					0		Lecture and 6 Exercise		6
2	Combi		, genera	nting functions, sol ex polygons, plana	_				ed sets,	lattices,
3	Learning Outcomes Students attending this course will - recognize discrete structures with far reaching connections to other parts of mathematics, - understand general discrete concepts and - be able to understand various counting concepts.									
4	Requirements for Participation recommended: Algorithmic Discrete Mathematics									
5		of Exam Iodule I		_						

• Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics, LaG Mathematik

9 Literature

- M. Aigner, Diskrete Mathematik, 5. Auflage, Vieweg, 2003.
- R. L. Graham, D. E. Knuth and O. Patashnik, Concrete Mathematics, Second edition, Addison-Wesley, Reading, MA, 1994.
- W. Koepf, Hypergeometric Summation. An Algorithmic Approach to Summation and Special Function Identities, AMS, 1998.
- J. Matoušek, J. Nešetril, Diskrete Mathematik. Eine Entdeckungsreise, Springer, 2002.
- R.P. Stanley, Enumerative Combinatorics, Volume I, Cambridge 1997.
- J.H. van Lint, R.M. Wilson: A Course in Combinatorics, Cambridge University Press, 2009.

10 Comment

recommended: Mathematics: Bachelor year 3 (opt), Teaching Degrees

Module Description

Module name **Numerical Linear Algebra** Module Frequency Credit Points | Workload Self-study Duration no. Every 4. 04-11-5 CP 150 h 105 h 1 Semester semester 0043/de **Language of Instruction** Person responsible for the Module Dr. rer. nat. Alf Gerisch German **Courses of the Module**

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0139-vu	Numerical Linear Algebra	0	Lecture and Exercise	3					
2	Study Content Systems of line problems.	t ear equations: iterative method	ls, singular value dec	omposition, ei	genvalue					
3		comes about the most important null lain, classify, and apply them.	merical methods of li	near algebra a	nd they					
4	_	for Participation Linear Algebra, Introduction	to Numerical Analysi	s or similar kno	owledge					
5	Form of Examination Final Module Examination:									
	Module Examination (Technical Examination, oral / written Examination, Standard)									
	test, except wheexam can be taken and co	Technical Examination): Usual nen there are only a small num aken in the form of an oral examination the first to mber of students taking the example.	ber of potential parti m. The decision abou wo weeks of the lectu	cipants. In this	case, the he exam					
6	Requirements Passing the Fac	on the Award of Credit Poin chprüfung	its							
7	Grading Final Module I	Examination:								
		e Examination (Technical Examination): 100%, Standard)	mination, oral / writt	en Examinatio	n,					
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics									
9	Literature Trefethen/Bau: Numerical Linear Algebra, SIAM Demmel: Applied Numerical Linear Algebra, SIAM Stoer/Bulirsch: Numerische Mathematik 2, Springer									
10	Comment recommended:	: Mathematics: Bachelor year 3	3 (num)							

Mod	lule na	me									
	Num	erical L	inear <i>A</i>	Algebra							
no. 04-1	lule l1- 3/en	Credit	Points 5 CP	Workload 150 h		- study 105 h	Duratio 1 Semes		Every 2	F requency Every 2. semester	
Lan Eng	guage o	of Instru	ıction			son respons rer. nat. Alf		the M	odule		
1	Course	es of the	e Modul	le	I						
	Course no. Course name		e name		Workload	(CP)	Form Teac		Contact Hours per Week		
	04-00-0139-vu Numerical Linear Algebra					0		Lectur Exerci		3	
2	Study Content Systems of linear equations: iterative methods, singular value decomposition, eigenvalue problems.								igenvalue		
3	Learning Outcomes Students know about the most important numerical methods of linear algebra and they are able to explain, classify, and apply them.										
4	_			rticipation Algebra, Introduc	tion t	to Numerica	l Analysi	s or si	milar kn	owledge	
5			ination Examina								
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writt	ten Ex	aminatio	on,	
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.										
6	6 Requirements on the Award of Credit Points Passing the Fachprüfung										
7	Gradin Final M	•	Examina	tion:							

	Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module
	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Trefethen/Bau: Numerical Linear Algebra, SIAM Demmel: Applied Numerical Linear Algebra, SIAM Stoer/Bulirsch: Numerische Mathematik 2, Springer
10	Comment recommended: Mathematics: Bachelor year 3 (num)

Mod	dule na	me									
	Intro	ductio	n to Ma	athematical Fina	nce						
no. 04-1	lule l1- 7/de	Credit	Points 5 CP	Workload 150 h		- study 105 h	Duratio 1 Seme		Frequency Every 2. semester		
	guage o	of Instru	ıction		Person responsible for the Module Prof. Dr. rer. nat. Michael Kohler						
1	Course no. Course name					Workload (CP) Form			n of hing	Contact Hours per Week	
	04-00-0	0084-vu	Introdu Finance	ction to Mathematic	al 0			Lectur Exerci		3	
2	Option Aktien	preises,	itragegr	enzen, Ein-Periode nel, Black-Scholes n.		•		_	-	chung des	
3	Studen - under - devel Studen	estand a op a bas ets are a	nd are a sic level ble to co	able to apply the not of understanding ontextualize subjects, and act ethical	of fir	nancial math atter within t	ematics he socia	l conte			

4 Requirements for Participation

recommended: Introduction to Stochastics, Probability Theory

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature

Bingham, Kiesel: Risk-Neutral Valuation;

Elliott, Kopp: Mathematics of Financial Markets;

Irle: Finanzmathematik;

Musiela, Rutkowski: Martingale Methods in Financial Modelling;

Pliska: Introduction to Mathematical Finance;

Shreve: Stochastic Calculus for Finance I (Discrete Time Models)

10 Comment

recommended: Mathematics: Bachelor year 3 (sto)

Module Description

Lan	guage of Instr	uction	Pers	son responsible fo	r the Module						
Ger	man and Englis	h	Prof	. Dr. rer. nat. Marc	Pfetsch						
1	Courses of the	e Module									
	Course no.	Course name		Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0027-vu	Discrete Optimization		0	Lecture and Exercise	6					
2	programs, poly	t ems of linear equalities an hedral combinatorics; me methods algorithms, heu	ethod	s: exact algorithms	•	~					
3	optimization.	comes ding this course will mast They will additionally be a oply relevant algorithms									
4	Requirements for Participation recommended: Introduction to Optimization, Algorithmic Discrete Mathematics										
5	Form of Exam Final Module I										
	 Module Examination (Technical Examination, oral / written Examination, Standard) 										
	test, except whexam can be taken and co	Technical Examination): Unen there are only a small aken in the form of an oracommunicated during the famber of students taking the	num l exa irst tv	ber of potential parm. The decision above weeks of the lec	rticipants. In thou	is case, the f the exam					
6	Requirements Passing the Fa	s on the Award of Credit chprüfung	Poin	ts							
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination,										
8	Weight Usability of th	:: 100%, Standard)									
	1	tik, M.Sc. Mathematik, M.	.Sc. N	Mathematics							
9		olsey: Integer and Combinary of Linear and Integer I		_	-						

	Korye, Vygen: Combinatorial Optimization, Springer 2012
10	Comment
	recommended: Mathematics: Master (opt)

Mo	dule na	me								
	Non	linear C	ptimiz	ation						
Mo ono. 04-007		Credit	Points 9 CP	Workload 270 h	Self	- study 180 h	Duratio 1 Semes		Freque Every 2 semest	2.
		of Instru				son respons				
	ı	d Englis			Prof	Dr. rer. na	t. Stefan	Ulbric	ch	
Cour		1	e Module Course name			Workload	(CP)	Form Teac		Contact Hours per Week
	04-00-0174-vu Nonlinear Optimization					0			e and se	6
	Metho	ds; meth		ds for unconstraine constrained probl	-				_	
3	SQP-methods Learning Outcomes Students - can model practical optimization instances as mathematical optimization problems - know methods for the solution of unconstrained optimization problems and their convergence properties - know the optimality theory of nonlinear optimization and are able to apply it - know methods for the solution of constrained optimization problems and their convergence properties									
4	Requirements for Participation recommended: Introduction to Optimization									
5	_	of Exam Module I								

• Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Geiger, Kanzow: Numerische Verfahren zur Lösung unrestringierter

Optimierungsaufgaben

Geiger, Kanzow: Theorie und Numerik restringierter Optimierungsaufgaben

Nocedal, Wright: Numerical Optimization

10 Comment

recommended: Mathematics: Master (opt)

Mod	dule na	me													
	Side-Channel Attacks on IT Systems														
no.							study	_		Freque	•				
04-11- 5 CP 150 l 0218/de				150 n		105 h 1 Semester Irregular			r 						
	guage c man	of Instru	ıction			Person responsible for the Module Apl. Prof. Dr. rer. nat. Werner Schindler					r				
1	Course	es of the	e Modul	le		•									
	Course	e no.	Course	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week				

	04-00-0218-vu Side-Channel Attacks on IT 0 Lecture and 3 Exercise
2	Study Content Mathematics: Modelling side-channel information in terms of stochastic processes, statistical decision theory, multivariate statistics, elementary statistical methods, elementary number theory (aims: understanding und developing side-channel attacks, optimal exploitation of side-channel information). Cryptography and IT security: Timing Attacks, power attacks.
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of side-channel attacks - are able to recognise the treated concepts in various fields of mathematics.
4	Requirements for Participation recommended: Analysis, Linear Algebra, Introduction to Stochastics or equivalent qualification required; familiarity of cryptography is desirable
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module
8	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature HO. Georgii: Stochastik - Einführung in die Wahrscheinlichkeitstheorie und Statistik. 5. Auflage, De Gruyter, Berlin 2015. F.E. Beichelt, D.C. Montgomery: Teubner Taschenbuch der Stochastik - Wahrscheinlichkeitstheorie, Stochastische Prozesse, Mathematische Statistik. Teubner, Wiesbaden 2003. O.J.W.F. Kardaun: Classical Methods of Statistics. Springer, Berlin 2005.

J. Buchmann: Einführung in die Kryptographie. 5. erw. Auflage, Springer, Berlin S. Mangard, E. Oswald, T. Popp: Power Analysis Attacks - Revealing the Secrets of Smart Cards. Springer, Berlin 2007.
and a number of relevant papers

10 Comment recommended: Mathematics: Bachelor year 3 (sto)

Mod	dule na	me								
	Com	plex Aı	nalysis	II						
no. 04-1	Module no. C1 04-11- 0227/en Language of 1		Points 5 CP	Workload 150 h	Self	-study 105 h	Study Duration 105 h		Freque Irregul	•
Lan Eng	~ ~	of Instru	ıction			on respons Dr. rer. na				r
1	Course	es of the	e Modu	le	!					
	Course no. Course		e name		Workload	(CP)	Forn Teac	n of hing	Contact Hours per Week	
	04-00-0226-vu Complex Analysis II					0		Lecture and Exercise		3
	fractio	ns, infin	ite prod	Möbius transforma ucts, Gamma func alytic functions; Li	tion,	elliptic fund	tions an	d curv		
3								he course		
4	Requirements for Participation recommended: Complex Analysis									
5		of Exam Module I Modul Standa	Examina e Exami		Exar	nination, ora	al / writt	ten Ex	aminatio	on,

	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading
	Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination,
	Weight: 100%, Standard)
_	
8	Usability of the Module
	B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature
	J.B. Conway: Complex Analysis I, II, Springer.
	L.V. Ahlfors: Complex Analysis, McGraw-Hill
	Chr. Pommerenke: Boundary Behaviour of Conformal Maps, Springer
	E. Freitag, R. Busam: Funktionentheorie 1, Springer
10	Comment
	recommended: Mathematics: Bachelor year 3 (alg)

Mod	Module name										
	Mathematical Foundations of Computer Science										
Module no. 04-11- 0233/de		Credit	Points 9 CP	Workload 270 h		3		Duration 2 Semester Frequ Every semes			
· '	German			Person responsible for the Module Prof. Dr. rer. nat. Martin Otto							
1	Course no. Cour			e name		Workload	(CP) Form			Contact Hours per Week	
	04-00-0090-vu Propositional Logic a Predicate Logic		U		0		Lectur Exerci	-	3		
	04-00-0	091-vu	Automa	ta, Formal Languas	ges	0		Lectur	e and	3	

	and Decidability	Exercise								
2	Study Content finite automata and regular languages, Kleene Theorem, Myhill–Nerode Theorem, grammars and Chomsky hierarchy, context-free languages, pumping lemmas, models of computation, PDA, Turing machines, decidability and recursive enumerability; propositional logic: compactness, complete proof calculi; first-order logic: structures and assignments, Skolemisation, Herbrand Theorem, compactness theorem, complete proof calculi (Gödel's completeness result), undecidability of first-order logic; optional: digressions on expressiveness and model checking									
3	Learning Outcomes Students understand and are able to apply th course. They have developed a basic level of basic computability theory and of methods of fundamental issues in theoretical computer so relevant concepts and ideas in related fields of science.	understanding of formal language mathematical logic in application cience. They are able to recognise	theory, to the							
4	Requirements for Participation recommended: solid mathematical foundations in Analysis and Linear Algebra									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examostandard) Fachprüfung (Technical Examination): Usual test, except when there are only a small number of an oral examination of students taking the examination of students taking the examination.	ly the exam is taken in form of a w ber of potential participants. In thi m. The decision about the form of wo weeks of the lecture, based on t	ritten s case, the the exam							
6	Requirements on the Award of Credit Poin Passing the Fachprüfung	ts								
7	Grading Final Module Examination: • Module Examination (Technical Examination (Weight: 100%, Standard)	nination, oral / written Examination	on,							
8	Usability of the Module B.Sc. Mathematik, Ergänzungsbereich M.Sc.									
9	Literature Hopcroft, Motwani, Ullman: Einführung in di Komplexitätstheorie Schöning: Theoretische Informatik – kurz gef	-	chen und							

		Boolos, Burgess, Jeffrey: Computability and Logic Burris: Logic for Mathematics and Computer Science Skripte (elektronisch unter www.mathematik.tu-darmstadt.de/~otto)
1	0	Comment recommended: Mathematics: Bachelor year 2

Mod	dule na									
Module no. 04-11- 0254		Credit Points 5 CP			Self-study 105 h		Duration 1 Semester		Frequency Irregular	
		of Instru d Englisi				on respons . Dr. rer. nat				
1	Course no. Cours		le e name		Workload	(CP)	Form of Teaching		Contact Hours per Week	
	04-11-0)254-vu	PDE II.O	Hydromechanics 0		0		Lectur		3
2	Study Content Development and analytical treatment of the fundamental equations of hydrodynamics, boundary layers, Euler equation, geophysical models									
3	Studen - under - devel - are al	rstand a op an ac ole to ex	nd are a dvanced stend th	able to apply the n level of understan eir knowledge in t ervised research ir	nding his fi	of hydrome eld		lts trea	ated in t	he course
4	_			rticipation onal Analysis, Part	ial D	ifferential E	quations	I		
5	_	of Exam Iodule E								
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writt	ten Ex	aminatio	on,

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Galdi: An introduction to the mathematical theory of the Navier-Stokes equations. Springer Verlag

Sohr: The Navier-Stokes equations. An elementary functional analytic approach.

Birkhäuser Verlag

Temam: Navier-Stokes equations. Theory and numerical analysis. North- Holland

Publishing Co.

10 Comment

recommended: Mathematics: Master (ana) Builds on "Partial Differential Equations I".

Upon approval, contents of two PDE II.X-courses may replace "Partial Differential Equations II" and can be combined with the content from "Partial Differential Equations I" as an "Advanced Course in Analysis".

Combinations of two or more PDE II.X-courses as additional courses require approval, too.

Module name										
Fourier Analysis										
Module no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-11- 0263/de	5 CP	150 h	105 h	1 Semester	Irregular					
Language	of Instruction		Person responsible for the Module							

Ger	man		Prof. Dr. rer. nat. Matt	hias Hieber							
1	Courses of the	e Module									
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week						
	04-00-0256-vu	Fourier Analysis	0	Lecture and Exercise	3						
2	Study Content Calderon-Zygmund singular integral operators, interpolation, Fourier transformation, multipliers										
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop a basic level of understanding of singular integrals and singular integral operators - are able to recognise the treated concepts in various fields of mathematics.										
4	Requirements for Participation recommended: Analysis, Gewöhnliche Differentialgleichungen, Complex Analysis.										
5	 Form of Examination Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. 										
6	Requirements Passing the Fac	s on the Award of Credit chprüfung	Points								
7	• Modul	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of the B.Sc. Mathema	ne Module atik, M.Sc Mathematik, M.	Sc. Mathematics								
9	Literature W. Rudin, Ree	lle und komplexe Analysis	s, Oldenbourg Verlag 19	999.							

	W. Rudin, Real and Complex Analysis, McGraw Hill, 3. Auflage 1987. E. Stein, Harmonic Analysis, Princeton University Press. L. Grafakos, Classical and Modern Fourier Analysis, Springer.
10	Comment recommended: Mathematics: Bachelor year 3 (ana)

Mod	dule na	me								
	Four	ier Ana	lysis							
Module no. Credit Points 04-11- 5 CP 0263/en		Points 5 CP	Workload 150 h	Self	- study 105 h	Duration 1 Semester		Frequency Irregular		
Language of Instruction English						son respons . Dr. rer. na				
1	Course	es of the	e Modul	le						
			Course	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
Ì	04-00-0)256-vu	Fourier	Analysis 0			Lecture and Exercise		3	
2	•			ngular integral ope	eratoi	rs, interpolat	ion, Fou	ırier tr	ansform	ation,
3	Studen - under - devel operate	rstand a op a bas ors	nd are a	able to apply the noof understanding the treated conce	of sir	ıgular integi	als and	singul	ar integi	
4	_			rticipation is, Gewöhnliche D	iffere	entialgleichu	ngen, Co	omple	x Analys	is.
5		of Exam Module F	Examina		Exar	nination or:	al / writt	ten Ex:	aminatio	on
		Standa		(100mmedi	Liui		, , ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	LOII LIA		~ ,

	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature W. Rudin, Reelle und komplexe Analysis, Oldenbourg Verlag 1999. W. Rudin, Real and Complex Analysis, McGraw Hill, 3. Auflage 1987. E. Stein, Harmonic Analysis, Princeton University Press. L. Grafakos, Classical and Modern Fourier Analysis, Springer.
10	Comment recommended: Mathematics: Bachelor year 3 (ana)

Module name											
Game Theory											
Module no. 04-11- 0312/de		Credit	Points 5 CP	Workload	150 h		elf-study Duration 105 h 1 Semes		1 1		•
1	Language of Instruction German 1 Courses of the Module				Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich						
	Course no. Cours		e name		Workload (CP)		Form Teac	_	Contact Hours per Week		
	04-10-0	320-vu	Game T	heory			0		Lectur Exerci		3

2 Study Content

Cooperative game theory: coalitions, solution concepts, stable sets, core, Shapley value, convex games.

Non-cooperative game theory: Sequential and strategic games, two-person and n-person games, zero-sum and non-zero-sum games, discrete and continuous games. Various concepts of solution of a game (e.g. Nash equilibrium). Fixed point theorems (e.g. Brouwer). Existence results (e.g. minimax theorem) and impossibility theorems. Algorithmic aspects. Applications.

3 Learning Outcomes

Students are familiar with different aspects of game theory, its use and its limitations. They understand fundamental (solution) concepts in cooperative or noncooperative game theory. They can illustrate and discuss abstract concepts using examples and construct game theoretic models of simple applications. They are able to prove and apply mathematical theorems to analyze games and to judge the results with respect to practical purposes. They can solve certain classes of games numerically.

4 Requirements for Participation

recommended: Analysis, Linear Algebra

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics

9 Literature

Osborne: An Introduction to Game Theory

Forg, Szép und Szidarovszky: Introduction to the Theory of Games

Krabs: Spieltheorie: Dynamische Behandlung von Spielen Berninghaus, Ehrhart und Güth: Strategische Spiele

10	Comment recommended: Mathematics: Bachelor year 3 (opt)

Mo	dule na Mat l		cal Fou	ndations of Qua	ntun	n Mechanic	:S			
no. 04-1	Module			Self-study		Duration 1 Semester		Frequency Irregular		
Language of Instruction German					son respons . Dr. rer. nat					
1			e Modu			T		1		
	Course no. Cour		Cours	e name		Workload	(CP)	Forn Teac	_	Contact Hours per Week
	04-10-0)328-vu	_	natical Foundations on m Mechanics	of 0		Lecture and 3 Exercise		3	
	Theore	em and t	ime dep	onsequences. Obse pendent Schröding rates and quantum	er Ed	quation. Con	•	-		
3	Studen mechal conseq from q	nics, to uences, uantum	ble to ex distingu to chec mechar	xplain and to inter ish assumptions m k the adequacy of nics, and to explain mechanis.	- notiva math	ated by phys nematical me	ics from ethods w	its ma hen ap	themati	cal problems
4	Requirements for Participation recommended: Content of the first two years of a B.Sc. Programme in Mathematics or Physics.									
5	_		nination Examina							
	•	Modul Standa		ination (Technical	Exar	nination, ora	al / writ	ten Ex	aminatio	on,

	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature J. v. Neumann: Mathematische Grundlagen der Quantenmechanik M. Reed, B. Simon: Methods of Modern Physics I. G.W. Mackey: Mathematical Foundations of Quantum Mechanics.
10	Comment recommended: Mathematics: Bachelor year 3 (alg)

Mod	Module name										
	Introduction to Axiomatic Set Theory										
Module no. 04-11- 0338/de		Credit Points 5 CP		Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Irregular		
German			Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher								
1	Course no. Course name			Workload	(CP)	Form of Teaching		Contact Hours per Week			
	04-10-0338-vu Introduction to Axiomatic So Theory		et	0		Lecture and Exercise		3			
2	Study Content We introduce the language and the axioms of ZFC (Zermelo-Fraenkel with Choice) and										

we explain how this system allows one to formulate and formalize mathematics as it is known today. We introduce the notions of ordinal and cardinal numbers and prove some basic facts about their arithmetics. Furthermore we discuss the Axiom of Choice and prove some of its equivalents like Zorn's lemma and the Well Ordering Theorem. **Learning Outcomes** Students master the language and basic methods of set theory like transfinite induction and recursion and basic cardinal (in)qualities. Moreover, they can recognize when the Axiom of Choice is used. **Requirements for Participation** recommended: solid mathematical foundations in Analysis and Linear Algebra Form of Examination 5 Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Standard) Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam. **Requirements on the Award of Credit Points** Passing the Fachprüfung Grading Final Module Examination: Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard) Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics Literature Lecture notes provided online. Further reading: Moschovakis "Notes on Set Theory" (Springer 2006)

10

Comment

recommended: Mathematics: Bachelor year 3 (log)

Мо	dule na	me								
	Арр	lied Ge	ometry	,						
no. 04-			Points 9 CP	Workload 270 h		- study 180 h	Duratio 1 Seme		Frequency Irregular	
	iguage o					son respons			odule	
1	Course	es of the	e Modu	le	<u> </u>					
	Course	ourse no. Course name Workload (CP)		(CP)	Form Teac	-	Contact Hours per Week			
	04-10-0)375-vu	Applied	Geometry		0		Lectur Exerci		6
3	Bernstein polynomials, Bézier curves, B-splines, spline curves, tensor product splines, spline surfaces, subdivision algorithms, smoothing of curves and surfaces, curvature estimation on polylines and triangular meshes. Learning Outcomes Students - understand basic mathematical principles of computer-aided geometric modeling of curves and surfaces - are able to assess their significance for theoretical and applied purposes - thoroughly understand the relationship between analytical properties of the involved function spaces and geometric properties of the manifolds they parametrise.									
4	_			rticipation ential Geometry						
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)									
	test, ex	cept wh	nen ther aken in	al Examination): Use are only a small the form of an oracated during the form of an oracated during the form of th	numi l exa	ber of poten m. The decis	tial part	icipant ut the	s. In thi form of	s case, the

prospective number of students taking the exam.

6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematics
9	Literature Hoschek und Lasser, Grundlagen der geometrischen Datenverarbertung, Teubner Prautzsch, Boehm und Paluszny, Bézier and B-Spline Techniques, Springer Peters und Reif, Subdivision surfaces, Springer Hoschek und Lasser, Grunglagen der geometrischen Datenverarbertung, Teubner Prautzsch, Boehm und Paluszny, Bézier and B-Spline Techniques, Springer Peters und Reif, Subdivision surfaces, Springer
10	Comment recommended: Mathematics: Master (geo)

Mod	Module name									
	Approximation theory									
Module no. 04-11-		Credit Points 9 CP		Workload 270 h	Self-study 180		Duration 1 Semester		Frequency Irregular	
Danguage of Instruction German and English					Person responsible for the Module Prof. Dr. rer. nat. Ulrich Reif					
1	Course	s of the	Modu	le						
	Course no. Course name			Workload (CP)		Form Teac		Contact Hours per Week		
	04-10-0	376-vu	Approxi	imation theory		0		Lectur Exerci		6
2	Study	Conten	ţ							
	Weierstrass approximation theorem, multivariate interpolation with polynomials, Bramble-Hilbert lemma, distance spline-control polygon, Schoenberg-Whitney theorem, natural and canonical spline interpolant, quasi interpolation, Jackson type theorems, uniform stability, orthogonality relations, smoothing splines, geometric approximation, finite element method									

3 Learning Outcomes

Students

- understand key aspects of linear uni- and multivariate approximations with polynomials and splines
- recognise the crucial role of dual functionals for stability and approximation properties
- develop an understanding of various methods of approximation and their properties
- can apply suitable methods of approximation to concrete problems

4 Requirements for Participation

recommended: Applied Geometry

5 Form of Examination

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Standard)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)

8 Usability of the Module

B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

de Boor, A Practical Guide to Splines, Springer Schumaker, Spline functions basic theory, Cambridge University Press Höllig, Finite element methods with B-splines, SIAM

10 Comment

recommended: Mathematics: Master (geo)

Mod	lule na	me									
	Nonl	inear F	unctio	nal Analysis							
Mod no. 04-1 038	1-	Credit	edit Points Workload 150 h		Self	f-study Duration 105 h		-		-	
	Language of Instruction German and English				son respons . Dr. rer. nat						
1	Course	es of the	e Modul	le							
	Course no. Course name		e name		Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-11-0)381-vu	Nonline	ar Functional Analy	sis	0		Lectur Exerci		3	
2	Study Content Fixed point theorems; calculus in Banach spaces; degree theory on R ^ n and in Banach spaces; bifurcation theory; monotone operators										
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course - develop an advanced level of understanding of nonlinear functional analysis - are able to extend their knowledge in this field - are able perform supervised research in this field										
4	-			rticipation onal Analysis							
5		of Exam Iodule E Modul	Examina	-	Exar	nination, or	al / writt	en Exa	aminati	on,	
		Standa					,			,	
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.										
6	Requirements on the Award of Credit Points										

	Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc Mathematik, M.Sc. Mathematik, M.Sc. Mathematics
9	Literature A. Ambrosetti, G. Prodi: A primer of nonlinear analysis. Cambridge University Press 1993 K. Deimling: Nonlinear functional analysis. Springer 1974 M. Ruzicka: Nichtlineare Funktionalanalysis. Springer 2004
10	Comment recommended: Mathematics: Master (ana)

Mod	Module name										
	Sobo	olev Sp	aces								
Mod no.	lule	Credit Points		Workload Self-		-study Duration		n Freque			
04-1 051	1- 4/en		5 CP	15	50 h		105 h	1 Semes	ster	Irregul	ar
	Language of Instruction German and English						on respons Prof. Dr. rer				r
1	Courses of the Module					чР					
	Course no. Course name		e name		Workload (C		(CP)	Form of Teaching		Contact Hours per Week	
	04-10-0)514-vu	Sobolev	Spaces			0		Lectur Exerci		3
2	Study	Conten	t								
		uction o ntial Eq		ev Spaces, Emb	bedd	ling a	nd trace the	eorems, <i>F</i>	Applic	ations to	o Partial
3	Learning Outcomes Students - understand and are able to apply the notions, methods and results treated in the course										
				of understand							

	- are able to recognise the treated concepts in various fields of mathematics.
4	Requirements for Participation recommended: Analysis, Linear Algebra, Integration Theory
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral / written Examination, Standard)
	Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module B.Sc. Mathematik, M.Sc Mathematik, M.Sc. Mathematics
9	Literature Adams, Fournier: Sobolev Spaces (Academic Press); Evans: Partial Differential Equations (AMS)
10	Comment recommended: Mathematics: Bachelor year 3 (ana)

Module na	Module name											
Com	Combined Module											
Module no. 04-13- 0001/de	Credit Points 8 CP	Workload 240 h	Self-study 240 h	Duration 1 Semester	Frequency Every 2. semester							
Language German	of Instruction		Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger									

1	Courses of th	e Module								
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
2	Study Content Siehe Teilmoo									
3	Learning Out Siehe jeweilig		d jeweiliges fachdidaktisch	nes Seminar						
4	Requirement Siehe Teilmoo	s for Participation lule								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard)									
6	Requirement	s on the Award of Cred	lit Points							
7			cal Examination, Technical	l Examination,	Weight:					
8	Usability of the Wahlpflichtbe	he Module reich, K-Modul								
9	Literature Siehe jeweilig	es Ergänzungsmodul un	d jeweiliges fachdidaktisch	nes Seminar						
10	Comment Die Mathematische Ergänzung soll jeweils vor dem Fachdidaktischen Seminar absolviert werden oder ggf. auch parallel. Als Mathematische Ergänzung können grundsätzlich alle BSc.Math-Module mit 5 CP oder mehr gewählt werden, die nicht bereits im Pflichtbereich des LaG vorgesehen sind. Die für den M.Ed.Math jeweils empfohlenen und im FB-Rat genehmigten Mathematischen Ergänzungen werden jeweils zum Semesterbeginn per Aushang bekannt gegeben. Ehemals: Mathematische Ergänzung und fachdidaktisches Seminar									

Mod	lule na	me										
	K mo	dule										
Mod no. 04-1		Credit	Points 8 CP	Workload 240 h	Self-study 240 h Duration 1 Semester				Frequency Every 2. semester			
1	guage c man	of Instru	ıction		Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger							
1	Course	s of the	e Modul	le								
Course no. Course name Workload (CP) Form of Teaching							_	Contact Hours per Week				
2	2 Study Content Siehe Teilmodule											
3	B Learning Outcomes Siehe jeweiliges Ergänzungsmodul und jeweiliges fachdidaktisches Seminar											
4	_	ements Ceilmod		rticipation								
5		of Exam Iodule E Modul	Examina		Exan	nination, Te	chnical E	Examir	nation, S	Standard)		
6	Requir	ements	on the	Award of Credit	Point	ts						
7	 Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) 											
8		ity of th										
9	Literat Siehe j		es Ergän	zungsmodul und j	eweil	iges fachdic	laktische	s Sem	inar			
	<u>I</u>											

10 Comment

Die Mathematische Ergänzung soll jeweils vor dem Fachdidaktischen Seminar absolviert werden oder ggf. auch parallel. Als Mathematische Ergänzung können grundsätzlich alle BSc.Math-Module mit 5 CP oder mehr gewählt werden, die nicht bereits im Pflichtbereich des LaG vorgesehen sind. Die für den M.Ed.Math jeweils empfohlenen und im FB-Rat genehmigten Mathematischen Ergänzungen werden jeweils zum Semesterbeginn per Aushang bekannt gegeben.

Ehemals:

Mathematische Ergänzung und fachdidaktisches Seminar

Mod	lule na	me									
Mod no. 04-1	lule			in Algebra Workload 540 h		- study 540 h	Duration 1 Semester		Frequency Every 2. semester		
Lan Geri	man	of Instru			Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	Course no. Course name Workload (CP) Form of Contact Hours per Week										
2	2 Study Content Algebraic Number Theory, Algebraic Geometry, Automorphic Forms, Spectral Theory, Operator Algebras, Infinite-dimensional Lie Algebras, Vertex Algebras										
3	Nach d		uch des	Moduls verstehen n diese auf typisch				-	pte der j	eweiligen	
4	_			rticipation etzung: Topologie,	, Alge	bra,Funktio	nalanaly	sis			
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard)										
6	Requir	ements	on the	Award of Credit	Poin	ts					

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)

8 Usability of the Module

Vertiefungsbereich Master Mathematik

9 Literature

Bruinier et al.: The 1-2-3 of Modular Forms,

Miyake: Modular Forms,

Hartshorne: Algebraic Geometry, Neukirch: Algebraic Number Theory, Kac: Infinite Dimensional Lie Algebras,

Frenkel, Ben-Zvi: Vertex Algebras and Algebraic Curves,

Bratelli, Robinson: Operator Algebras and Statistical Machanics I, II,

Takesaki: Theory of Operator Algebras

10 Comment

Verantwortlich: Studiendekan

Module Description

Мо	dule na	me									
	Adv	anced (Course	in Geometry a	and	App	roximatio	n			
no. 04-		Credit	Points 18 CP	Workload 540		Self-	study 540 h	Duratio 1 Semes		Freque Every 2 semeste	2.
	man	of Instr	uction e Modul	le			on respons iendekan*ii				
	Cours	e no.	Course	e name			Workload	(CP)	Form Teac	_	Contact Hours per Week
2	Es soll		ieftes St	rudium eines Ge verarbeitung sta				U			

(Mannigfaltigkeiten; Metriken Zusammenhänge, Geodätische, Krümmung; Sätze von

(Minimalflächen und Flächen konstanter mittlerer Krümmung, Weierstrass-Darstellung, Plateau-Problem, Satz von Bernstein, Stabilität, konjugierte Flächen etc.) Geometrische Datenverarbeitung (Bezierkurven und -flächen, Splinekurven und -flächen, B-Splines, Konvertierungsmethoden, Abstandsformeln, Flächen beliebiger Topologie, Subdivision)

Hopf-Rinow, Synge, Myers, Klingenberg) Variationsprinzipien und Geometrie

Splineapproximation (Satz von Weierstrass, Interpolation, Quasi- Interpolation, Approximation, Stabilität der B-Splines, Jacksonsätze, Bernsteinsätze Orthogonalitätsrelationen, B-Splines als Finite Elemente) 3 **Learning Outcomes** Die Studierenden sind in der Lage, geometrische Probleme zu analysieren und zu modellieren. Abhängig von der speziellen Veranstaltung kommen hierzu die Fähigkeiten zu axiomatisieren und zu abstrahieren, Methoden der Analysis auf geometrische Probleme anzuwenden, oder konkrete Geometrien unter Verwendung algorithmischer Prinzipien zu konstruktieren und approximieren. **Requirements for Participation** Differentialgeometrie Form of Examination Final Module Examination: Module Examination (Technical Examination, Technical Examination, Standard) 6 **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) 8 Usability of the Module Literature beispielhaft seien genannt: Do Carmo: Riemannian Geometry Gallot, Hulin, Lafontaine: Riemannian Geometry Dierkes, Hildebrandt, Küster, Wohlrab: Minimal Surfaces Hoschek-Lasser: Grundlagen der Geometrischen Datenverarbeitung de Boor: A Practical Guide to Splines Hoellig: Finite Element Methods with B-Splines Comment Verantwortlich: Studiendekan

Module Description

Module name

Advanced Course in Mathematical Logic

Mod no. 04-1		Credit	Points 18 CP	Workload 540 h		- study 540 h	Duratio 1 Seme		Freque Every 2 semest	y 2.	
Lan Geri		of Instru	ıction			on respons liendekan*i					
1	Course	es of the	e Modu	le	1						
	Course	e no.	Cours	е пате		Workload	Forn Teac	n of ching	Contact Hours per Week		
Einführung in die höhere mathematische Logik mit ausgewählten Kapiteln zu Modelltheorie, Beweistheorie, Rekursionstheorie, Berechenbarkeit#47; Komplexität, etc. Je nach Dozent und Ausprägung der Vertiefungsrichtung umfasst das Modul typischerweise spezialisierte Einführungen in zwei Schwerpunktgebiete aus den Bereichen Beweistheorie, Typen- und Kategorientheorie, Berechenbarkeitstheorie, Komplezitätsheorie, Modelltheorie, mit dem jeweiligen Anwendungswendungsbezug in der betreffenden Forschungsrichtung, wie z.B. -Beweisinterpretationen, proof mining -Semantik funktionaler Programmierung; kategorielle Semantik konstruktiver Logikkalkuele -endliche#47;algorithmische Modelltheorie und die Modelltheorie spezieller Logiken - reelle Berechenbarkeits- und Komplexitätstheorie											
3	Die Stu der ang erreich	gewandt en, das	len erw ten Log: sie im I	erben vertiefende ik. Sie sollen dabei Prinzip befähigt, Pr vorbenes Wissen ir	i ein i cobler	nhaltliches nstellungen	und met der akti	hodisc	hes Vers	ständnis	
4	_			rticipation hematische Logik							
5 6	Final M		Examina e Exam				chnical I	Exami	nation,	Standard)	
7	•	Module F Modul 100%,	e Exam Standai	ination (Technical rd)	Exan	nination, Te	chnical I	Exami	nation, V	Weight:	
8 Usability of the Module											

	Vertiefungsbereich Master Mathematik
9	Literature exemplarisch, neben Standardwerken: Kohlenbach: Applied Proof Theory: Proof Interpretations and their Use in Mathematics, Springer, 2008 Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific, 2006 Goranko, Otto: Model Theory of Modal Logics, in: Handbook of Modal Logic, Elsevier, 2007
10	Comment Verantwortlich: Studiendekan

Mod	dule na										
no. 04-1	dule			in Numerical An Workload 540 h	Self	-study	Duratio 1 Semes		Frequency Every 2. semester		
	guage o man	of Instru	ıction		Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	Course	es of the		le e name		Workload	(CP)	Form Teac	_	Contact Hours per Week	
2	Auswal Randw Parame	ertprob eteropti	en Ther leme, di mierung	nengebieten: steif Ifferential- agebrai g, Optimlasteuerur nen, elliptische, pa	ische ngspro	Gleichunger obleme, Diff	n, Sensiti erenzenv	vitätsa verfah	analyse, ren, Finit		
3	Learning Outcomes Kenntnis der wesentlichen Konstruktionsprinzipien numerischer Lösungsverfahren für Differentialgleichungen, Kenntnis von Vor- und Nachteilen, Einsatzbereichen, Genauigkeit, Aufwand etc. Fähigkeit, für gegebene Anwendungsaufgaben, geeignete Software auswählen und adaptieren sowie Fachartikel der aktuellen Forschung verstehen und diskutieren zu können.										
4	_			rticipation ifferentailgleichur	ngen						

5	Form of Examination
	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)
8	Usability of the Module
	Vertiefungsbereich Master Mathematik
9	Literature Strehmel, Weiner: Numerik gewöhnlicher Differentialgleichungen, Grossmann, Roos: Numerik partieller Differentialgleichungen, Brenan, Campbell, Retzold: Numerical Solution of IVPs in DAEs, LeVeque: Finite Volume Methods for Hyperbolic Problems, Larsson, Thomee: PDE with Numerical Methods, Quarteroni, Valli: Numerical Approximation of PDE
10	Comment Verantwortlich: Studiendekan

Mod	Module name											
	Advanced Course in Analysis											
no. 04-1	lule 13- 1/de	Credit Points 18 CP			Self-study 540 h		Duration 1 Semester		Frequency Every 2. semester			
Gen	Language of InstructionPerson responsible for the ModuleGermanStudiendekan*in des Fachbereichs 04											
1	Course	es of the		e name		Workload	(CP)	Form Teac		Contact Hours per Week		
2	Study Content Untersuchung von Existenz, Eindeutigkeit und Regularität von Lösungen linearer und nichtlinearer partieller Differentialgleichungen mit funktionalanalytischen Methoden; je											

nach Dozent erfolgt eine Ausprägung in Richtung elliptischer, parabolischer und hyperbolischer Gleichungen mit Anwendungen z.B. in der Strömungsmechanik oder den Materialwissenschaften **Learning Outcomes** Nach Besuch der Veranstaltung - sind die Studierenden mit aktuellen Problemen für partielle Differentialgleichungen aus verschiedenen Anwendungsgebieten (z.B. Strömungsmechanik, Materialwissenschaften) vertraut und können diese erläutern, - beherrschen sie moderne funktionalanalytische Methoden zum Studium von partiellen Differentialgleichungen und können diese auf einfache konkrete Probleme anwenden, - kennen sie wesentliche Eigenschaften von Sobolevräumen und können deren Rolle in der Lösungstheorie partieller Differentialgleichungen erklären. **Requirements for Participation** je nach Schwerpunktsetzung Form of Examination Final Module Examination: Module Examination (Technical Examination, Technical Examination, Standard) 6 **Requirements on the Award of Credit Points** Grading Final Module Examination: Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard) Usability of the Module 8 Vertiefungsbereich Master Mathematik 9 Literature Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order; Amann: Linear and Quasilinear Parabolic Problems; Dafermos: Hyperbolic Conservation Laws in Continuum Physics; Galdi: An Introduction to the Theory of the Navier-Stokes Equations; 10 Comment Verantwortlich: Studiendekan

Module Description

Module name

	Adva	anced (Course	in Optimization								
no. 04-2	dule 13- 3/de	Credit	Points 18 CP	Workload 540 h	Self	- study 540 h	Duratio 1 Semes		Freque Every 2 semeste	2.		
	guage (man	of Instru	uction		Person responsible for the Module Studiendekan*in des Fachbereichs 04							
1	Course	es of the	e Modu	le								
	Course no. Course name Study Content					Workload	(CP)	Form Teac	_	Contact Hours per Week		
2 Study Content Modelling relevant topics as problems in optimization; Theory: conditions for optimality, polyhedral combinatorics. Methods: exact algorithms for integer linear programs; methods for non-linear problems with and without boundary conditions; approximation algorithms, heuristics, relaxations												
3	After having attended the module, students will have a good command of the theoretical fundamentals of discrete and nonlinear optimization. The students are additionally able to solve modeling problems and to analyze and apply relevant algorithms.											
4	_			rticipation imierung								
5	_	Iodule I	ination Examina e Exam		Exan	nination, Te	chnical E	Examii	nation,	Standard)		
6	Requir	ements	on the	Award of Credit	Poin	ts						
7	Grading Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Weight: 100%, Standard)											
8		ity of thungsmo	ne Modu dul	ıle								
9 Literature Geiger, Kanzow: Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben Nemhauser, Wolsey: Integer and Combinatorial Optimization Nocedial, Wright: Numerical Optimization Schrijver: Theory of Linear and												

	Integer Programming	
10		
	Verantwortlich: Studiendekan	

Mod	dule na	me									
	Adva	anced C	Course	in Stochastics							
no. 04-1	lule 13- 5/de	Credit	Points 18 CP	Workload 540 h		-study 540 h	Duratio		Freque Every 2 semeste	•	
	guage (man	of Instru	action		Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1 Courses of the Module											
	Course no. Course name Workload (CP) Form of Teaching Hours per Week										
2	Study Content eine Auswahl aus folgenden Themengebieten: Mathematische Statistik, statistische Entscheidungstheorie, stochastische Analysis, Analyse und Modellierung stochastischer (partieller) Differentlialgleichungen, Finanzmathematik in stetiger Zeit										
3	Learning Outcomes Nach dem Besuch des Moduls können die Studierenden - komplexe zufällige Phänomene modellieren und analysieren, - zentrale Resultate aus einer aktuellen Forschungsrichtung der Stochastik und ihre Konsquenzen beschreiben, anwenden, auf verwandte Problemstellungen übertragen und deren Anwendung in der Praxis beurteilen.										
4	_			rticipation hkeitstheorie und	ggf.	Einführung i	in die Fir	nanzm	athemat	ik	
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, Technical Examination, Standard)										
6	Requirements on the Award of Credit Points										
7	Gradir	ng									

	Final Module Examination:
	Module Examination (Technical Examination, Technical Examination, Weight:
	100%, Standard)
8	Usability of the Module
	Vertiefungsbereich Master Mathematik
9	Literature
	Beispielhaft seien genannt:
	Pestmann: Mathematical Statistics
	Karatzas, Shreve: Brownian Motion and Stochastic Calculus
	Elliott, Kopp: Mathematics of Financial Markets
	Bain, Crisone: Fondamentals of Stochastic Filtering
	Da Brato, Zabczyk: Stochastic Equation in finite Arguments
10	Comment
	Verantwortlich: Studiendekan

Mod	dule na	me									
		tional nbined		in Mathema e)	tic	s and	d Subject	Specifi	c Semi	inar in	Didactics
no. 04-1	dule 13- 0/de	Credit	Points 8 CP	Workload 240	h		study 240 h	Durati 1 Seme		Freque Every 2 semest	2.
	guage o man	of Instru	ıction				on respons Dr. phil. na				
1	Course	es of the	e Modul	le							
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per Week
2	•	Conten Ceilmod									
3	Learni	ng Outo	comes								

	Siehe jeweiliges Ergänzungsmodul und jeweiliges fachdidaktisches Seminar
4	Requirements for Participation Siehe Teilmodule
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Wahlpflichtbereich, K-Modul
9	Literature Siehe jeweiliges Ergänzungsmodul und jeweiliges fachdidaktisches Seminar
10	Comment

Mod	lule naı	me									
	Adva	nced C	Course	n Algebra							
Mod no. 04-1 0103		Credit	Points 18 CP	Workload	540 h		study 540 h	Duratio 1 Seme		Freque Every 4 semest	4.
Lang Gerr 1			e Modul	le			on respons . Dr. rer. nat				r
	Course			e name			Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-13-0	301-vu	Advance	ed Course in	Algebra	a 1	0		Lectur Exerci	-	0

04-13-0302-vu	Advanced Course in Algebra 2	0	Lecture and Exercise	0
04-13-0303-vu	Advanced Course in Algebra 3	0	Lecture and Exercise	0
04-13-0304-vu	Advanced Course in Algebra 4	0	Lecture and Exercise	0
04-13-0305-vu	Advanced Course in Algebra 5	0	Lecture and Exercise	0
04-13-0306-vu	Advanced Course in Algebra 6	0	Lecture and Exercise	0

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (alg)" to the extent of 18-20 CP (2x9 or 1x9+2x5 or 4x5). Typical topics include:

algebraic number theory, algebraic geometry, arithmetic geometry, automorphic forms, spectral theory, operator algebras, infinite-dimensional lie algebras, vertex algebras

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of algebra
- have an overview of the relations of these branches with each other and their place within the overall context of algebra
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

Passing "Algebra"

5 Form of Examination

Final Module Examination:

• Module Examination (Technical Examination, oral Examination, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

cf. e.g. references to the courses:

- Algebraic Geometry
- Arithmetical Geometry I and II
- Algebraic Number Theory
- Automorphic Forms
- Spectral Theory and Operator Algebras

04-13-0301-vu | Advanced Course in Algebra 1

04-13-0302-vu | Advanced Course in Algebra 2

04-13-0303-vu | Advanced Course in Algebra 3

04-13-0304-vu | Advanced Course in Algebra 4

04-13-0305-vu | Advanced Course in Algebra 5

04-13-0306-vu | Advanced Course in Algebra 6

- Lie Algebras
- Vertex Algebras

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module Description

Mod	Module name										
	Adv	anced C	ourse	in Algebra	l						
Mod no. 04-1		Credit	Points 18 CP	Workload	540 h		study 540 h	Duratio 1 Semes		Frequent Every 2. semeste	
Lan Eng	~ ~	of Instru	ıction				on respons Dr. rer. na				
1	Course	es of the	e Modul	le							
	Course	e no.	Cours	e name			Workload	(CP)	Form Teac		Contact Hours per Week

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2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (alg)" to the extent of 8+4 contact hours per week (2x(4+2) or 1x(4+2)+2x(2+1) or 4x(2+1)). Typical

topics include:

algebraic number theory, algebraic geometry, arithmetic geometry, automorphic forms, spectral theory, operator algebras, infinite-dimensional lie algebras, vertex algebras

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of algebra
- have an overview of the relations of these branches with each other and their place within the overall context of algebra
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

Passing "Algebra"

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

cf. e.g. references to the courses:

- Algebraic Geometry
- Arithmetical Geometry I and II
- Algebraic Number Theory
- Automorphic Forms
- Spectral Theory and Operator Algebras
- Lie Algebras
- Vertex Algebras

10 Comment

Students acquire the agreed upon contents and skills independently, for example by

attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module Description

Module na	ıme				
Adv	anced Course	in Geometry and	d Approximatio	n	
Module no. 04-13- 0105/de	Credit Points 18 CP		Self-study 540 h	Duration 1 Semester	Frequency Every 6. semester
Language German	of Instruction		Person respons Prof. Dr. rer. nat		odule

1 Courses of the Module

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-13-0501-vu	Advanced Course in Geometry and Approximation 1	0	Lecture and Exercise	0
04-13-0502-vu	Advanced Course in Geometry and Approximation 2	0	Lecture and Exercise	0
04-13-0503-vu	Advanced Course in Geometry and Approximation 3	0	Lecture and Exercise	0
04-13-0504-vu	Advanced Course in Geometry and Approximation 4	0	Lecture and Exercise	0
04-13-0505-vu	Advanced Course in Geometry and Approximation 6	0	Lecture and Exercise	0
04-13-0506-vu	Advanced Course in Geometry and Approximation 6	0	Lecture and Exercise	0

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (geo)" to the extent of 18-20 CP (2x9 or 1x9+2x5 or 4x5). Typical topics from either differential or applied geometry and approximation theory include:

Riemannian geometry, geometric variational problems; or applied geometry, approximation theory

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of geometry and approximation
- have an overview of the relations of these branches with each other and their place within the overall context of geometry and approximation

	- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches
4	Requirements for Participation Passing "Differential Geometry"
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral Examination, Standard) Fachprüfung: oral
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Mod	Module name									
	Adv	anced C	Course	in Geometry and	l App	roximatio	n			
Mod no. 04-1 010		Credit	Points 18 CP	Workload 540 h		- study 540 h	Duratio 1 Semes		Frequer Every 6. semeste	
		of Instru	ıction		Person responsible for the Module					
Eng	пѕп				Prof. Dr. rer. nat. Ulrich Reif					
1 Courses of the Module										
	Course	e no.	Course	e name		Workload	(CP)	Form Teac		Contact Hours

				per Week
04-13-0501-vu	Advanced Course in Geometry and Approximation 1	0	Lecture and Exercise	0
04-13-0502-vu	Advanced Course in Geometry and Approximation 2	0	Lecture and Exercise	0
04-13-0503-vu	Advanced Course in Geometry and Approximation 3	0	Lecture and Exercise	0
04-13-0504-vu	Advanced Course in Geometry and Approximation 4	0	Lecture and Exercise	0
04-13-0505-vu	Advanced Course in Geometry and Approximation 6	0	Lecture and Exercise	0
04-13-0506-vu	Advanced Course in Geometry and Approximation 6	0	Lecture and Exercise	0

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (geo)" to the extent of 8+4 contact hours per week (2x(4+2) or 1x(4+2)+2x(2+1) or 4x(2+1)). Typical topics from either differential or applied geometry and approximation theory include: Riemannian geometry, geometric variational problems; or applied geometry, approximation theory

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of geometry and approximation
- have an overview of the relations of these branches with each other and their place within the overall context of geometry and approximation
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

Passing "Differential Geometry"

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

	Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)
8	Usability of the Module
	M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Mod	dule nan	ne								
	Adva	nced (Course	in Mathematical	Log	ic			1	
Module no. Cred		Credit	Points Workload		Self	-study	Duratio	on	Frequ	ency
04-1 010	13- 7/de		18 CP	540 h		540 h	1 Seme	ster	Irregu	lar
Language of Instruction Person responsi										
	man				Prof	Dr. rer. na	t. Thoma	is Stre	icher	
1	Courses	s of the	e Modu	le						
	Course	Course no. Cours		e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
			Advanced Course in Mathematical Logic 1			0		Lectur Exerci		0
			Advanced Course in Mathematical Logic 2			0		Lectur Exerci		0
			Advanced Course in Mathematical Logic 3			0		Lectur Exerci	-	0
	04-13-0704-vu Advanc			ced Course in matical Logic 4		-		Lectur Exerci	-	0
				ced Course in matical Logic 5		0		Lecture and Exercise		0
	04-13-07	706-vu	_	ed Course in natical Logic 6		0		Lectur Exerci		0
2	Study C	Conten	t							
	topics o	f cours	es with	upon between stuc comment "recomn x9+2x5 or 4x5). T	nend	ed: Mathema	atics: Ma	•		

model theory, proof theory, recursion theory, computability/ complexity, type theory and category theory 3 **Learning Outcomes** Students - understand the fundamental principles, notions and methos of the topics chosen - are able to apply these to typical problems - have an advanced understanding of several branches of mathematical logic - have an overview of the relations of these branches with each other and their place within the overall context of mathematical logic - are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches **Requirements for Participation** Passing "Introduction to Mathematical Logic" 5 Form of Examination Final Module Examination: Module Examination (Technical Examination, oral Examination, Standard) Fachprüfung: oral **Requirements on the Award of Credit Points** 6 Passing the Fachprüfung 7 Grading Final Module Examination: Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard) Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics Literature examples of specialised literature include: Kohlenbach: Applied Proof Theory: Proof Interpretations and their Use in Mathematics, Springer, 2008 Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific, Goranko, Otto: Model Theory of Modal Logics, in: Handbook of Modal Logic, Elsevier, 2007 Comment Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module name

Adva	Advanced Course in Mathematical Logic									
Module no. 04-13- 0107/en	Credit Points 18 CP		•	Duration 1 Semester	Frequency Every 2. semester					
Language (English	of Instruction		Person responsible for the Module Prof. Dr. rer. nat. Thomas Streicher							
L11511311			Fior. Dr. fer. flat. Thomas Stretcher							

Courses of the Module

Courses of the	c Module			
Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-13-0701-vu	Advanced Course in Mathematical Logic 1	0	Lecture and Exercise	0
04-13-0702-vu	Advanced Course in Mathematical Logic 2	0	Lecture and Exercise	0
04-13-0703-vu	Advanced Course in Mathematical Logic 3	0	Lecture and Exercise	0
04-13-0704-vu	Advanced Course in Mathematical Logic 4	0	Lecture and Exercise	0
04-13-0705-vu	Advanced Course in Mathematical Logic 5	0	Lecture and Exercise	0
04-13-0706-vu	Advanced Course in Mathematical Logic 6	0	Lecture and Exercise	0

Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (log)" to the extent of 8+4 contact hours per week (2x(4+2) or 1x(4+2)+2x(2+1) or 4x(2+1)). Typical topics include:

model theory, proof theory, recursion theory, computability/ complexity, type theory and category theory

Learning Outcomes 3

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of mathematical logic
- have an overview of the relations of these branches with each other and their place within the overall context of mathematical logic
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4	Requirements for Participation
	Passing "Introduction to Mathematical Logic"
5	Form of Examination Final Module Examination:
	Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)
	Fachprüfung: oral
6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature examples of specialised literature include: Kohlenbach: Applied Proof Theory: Proof Interpretations and their Use in Mathematics, Springer, 2008 Streicher: Domain-Theoretic Foundations of Functional Programming, World Scientific, 2006 Goranko, Otto: Model Theory of Modal Logics, in: Handbook of Modal Logic, Elsevier, 2007
10	Comment Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module name									
Advanced Course in Numerical Analysis									
Module no. 04-13- 0109/de	Credit Points 18 CP	Workload 540 h	Self-study 540 h	Duration 1 Semester	Frequency Every 4. semester				
-	of Instruction		Person responsible for the Module Prof. Dr. rer. nat. Jan Giesselmann						

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-13-0901-vu	Advanced Course in Numerical Analysis 1	0	Lecture and Exercise	0
04-13-0902-vu	Advanced Course in Numerical Analysis 2	0	Lecture and Exercise	0
04-13-0903-vu Advanced Course in Nume Analysis 3		0	Lecture and Exercise	0
04-13-0904-vu	Advanced Course in Numerical Analysis 4	0	Lecture and Exercise	0
04-13-0905-vu	Advanced Course in Numerical Analysis 5	0	Lecture and Exercise	0
04-13-0906-vu	Advanced Course in Numerical Analysis 6	0	Lecture and Exercise	0

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (num)" to the extent of 18-20 CP (2x9 or 1x9+2x5 or 4x5). Typical topics include:

Numerical methods for partial differential equations with uncertain data, efficient methods for data assimilation, scalable linear solvers, finite element, finite volume, or boundary element methods; applications in fluid dynamics or solid mechanics.

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of numerical analysis
- have an overview of the relations of these branches with each other and their place within the overall context of numerical analysis
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

Passing "Numerical Analysis of Ordinary Differential Equations"

5 Form of Examination

Final Module Examination:

• Module Examination (Technical Examination, oral Examination, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Strehmel, Weiner: Numerik gewöhnlicher Differentialgleichungen Grossmann, Roos: Numerik partieller Differentialgleichungen Brenan, Campbell, Retzold: Numerical Solution of IVPs in DAEs LeVeque: Finite Volume Methods for Hyperbolic Problems

Larsson, Thomee: PDE with Numerical Methods Quarteroni, Valli: Numerical Approximation of PDE

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Mod	lule na	me								
	Adva	anced C	Course	in Numerical An	alysis	5				
Module no. Credi 04-13- 0109/en		Credit	Points 18 CP	Workload 540 h	Self-study 540 h Durati		Duratio 1 Semes	Every 2		
Language of Instruction English			action		Person responsible for the Module Prof. Dr. rer. nat. Jan Giesselmann					
1	Course	es of the	e Modul	le						
	Course no.		Course name			Workload	(CP)	Form Teac		Contact Hours per Week
	04-13-0)901-vu	Advance Analysis	ed Course in Numer s 1	ical	0		Lectur Exerci		0
			Advance Analysis	vanced Course in Numerical alysis 2		"		Lectur Exerci		0
	04-13-0)903-vu	Advance Analysis	ed Course in Numer 3 3	ical	0		Lectur Exerci		0
	04-13-0)904-vu	Advance Analysis	ed Course in Numer s 4	ical	0		Lectur Exerci		0
	04-13-0)905-vu	Advance	ed Course in Numer	ical	0		Lectur	e and	0

	Analysis 5		Exercise	
•	Advanced Course in Numerical Analysis 6	0	Lecture and Exercise	0

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (num)" to the extent of 8+4 contact hours per week (2x(4+2) or 1x(4+2)+2x(2+1) or 4x(2+1)). Typical topics include:

Numerical methods for partial differential equations with uncertain data, efficient methods for data assimilation, scalable linear solvers, finite element, finite volume, or boundary element methods; applications in fluid dynamics or solid mechanics.

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of numerical analysis
- have an overview of the relations of these branches with each other and their place within the overall context of numerical analysis
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

Passing "Numerical Analysis of Ordinary Differential Equations"

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Strehmel, Weiner: Numerik gewöhnlicher Differentialgleichungen Grossmann, Roos: Numerik partieller Differentialgleichungen Brenan, Campbell, Retzold: Numerical Solution of IVPs in DAEs LeVeque: Finite Volume Methods for Hyperbolic Problems Larsson, Thomee: PDE with Numerical Methods Quarteroni, Valli: Numerical Approximation of PDE

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module Description

Module name								
Advanced Course in Analysis								
Module no. 04-13- 0111/de	Credit Points 18 CP	Workload 540 h	Self-study 540 h	Duration 1 Semester	Frequency Every 4. semester			
	of Instruction		Person responsible for the Module					
German			Prof. Dr. rer. nat. Matthias Hieber					

1 Courses of the Module

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-13-1101-vu	Advanced Course in Analysis 1	0	Lecture and Exercise	0
04-13-1102-vu	Advanced Course in Analysis 2	0	Lecture and Exercise	0
04-13-1103-vu	Advanced Course in Analysis 3	0	Lecture and Exercise	0
04-13-1104-vu	Advanced Course in Analysis 4	0	Lecture and Exercise	0
04-13-1105-vu	Advanced Course in Analysis 5	0	Lecture and Exercise	0
04-13-1106-vu	Advanced Course in Analysis 6	0	Lecture and Exercise	0

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (ana)" to the extent of 18-20 CP (2x9 or 1x9+2x5 or 4x5). Typical topics include: Investigation of existence, uniqueness and regularity of linear and nonlinear partial differential equations with modern methods and focus on elliptic parabolic or hyperbolic

differential equations with modern methods and focus on elliptic, parabolic or hyperbolic equations with applications e.g. in fluid mechanics or materials science.

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of analysis
- have an overview of the relations of these branches with each other and their place within the overall context of analysis
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

depending on the topics covered

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral Examination, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order;

Amann: Linear and Quasilinear Parabolic Problems;

Dafermos: Hyperbolic Conservation Laws in Continuum Physics; Galdi: An Introduction to the Theory of the Navier-Stokes Equations;

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module Description

Module name Advanced Course in Analysis Module Credit Points Workload Self-study Duration Frequency no. 18 CP 540 h 540 h 1 Semester Every 2.

04-1 011	13- 1/en							semes	ter
Eng				Person responsible for the Module Prof. Dr. rer. nat. Matthias Hieber					
1	Course no.	e Module Course			Workload	(CP)	Form of Teaching		Contact Hours per Week
		Advanced Course in Analysis 1 Advanced Course in Analysis 2			0		Lectur Exerci	se	0
			l Course in Analys		0		Exerci Lectur	se re and	0
	04-13-1104-vu	Advance	l Course in Analys	is 4	0		Exerci Lectur Exerci	e and	0
			l Course in Analys		0			re and	0
	04-13-1106-vu	Advance	vanced Course in Analysis 6 0 Lecture Exercise			0			
	topics of cours of 8+4 contac topics include: Investigation of differential equ	es with c t hours p f of existen uations w	pon between stu- omment "recommer week (2x(4+2)) ce, uniqueness are tith modern metherions e.g. in fluid	nendel) or nd re	ed: Mathema 1x(4+2)+2x gularity of li and focus on	atics: Max(2+1) near and lelliptic	aster (a or 4x(2 d nonli , parab	ana)" to 2+1)). near pa oolic or	the extent Typical artial
3	Learning Outcomes Students - understand the fundamental principles, notions and methos of the topics chosen - are able to apply these to typical problems - have an advanced understanding of several branches of analysis - have an overview of the relations of these branches with each other and their place within the overall context of analysis - are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches								
4	Requirements depending on		-						
5	Form of Exam Final Module I		ion:						

	 Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)
	Fachprüfung: oral
6	Requirements on the Award of Credit Points
	Passing the Fachprüfung
7	Grading Final Module Examination:
	Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order; Amann: Linear and Quasilinear Parabolic Problems; Dafermos: Hyperbolic Conservation Laws in Continuum Physics; Galdi: An Introduction to the Theory of the Navier-Stokes Equations;
10	Comment Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module name											
	Advanced Course in Optimization										
Module no. Credit Points 04-13- 18 CP 0113/de		Workload	540 h				Duration 1 Semester Frequence Every semes		4.		
Language of Instruction German Person responsible for the Module Prof. Dr. rer. nat. Stefan Ulbrich Courses of the Module											
	Course	no.	Course	e name			Workload	(CP)	Form Teac	-	Contact Hours per Week
	04-13-13	301-vu	Advance Optimiz	ed Course in ation 1			0		Lectur Exerci	-	0
	04-13-13	302-vu	Advance	ed Course in			0		Lectur	e and	0

	Optimization 2		Exercise	
04-13-1303-vu	Advanced Course in Optimization 3	0	Lecture and Exercise	0
04-13-1304-vu	Advanced Course in Optimization 4	0	Lecture and Exercise	0
04-13-1305-vu	Advanced Course in Optimization 5	0	Lecture and Exercise	0
04-13-1306-vu	Advanced Course in Optimization 6	0	Lecture and Exercise	0
Ctuder Comton	<u>.</u>	•	•	

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (opt)" to the extent of 18-20 CP (2x9 or 1x9+2x5 or 4x5). Typical topics include: nonlinear optimization; discrete optimization

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of optimization
- have an overview of the relations of these branches with each other and their place within the overall context of optimization
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

Passing "Introduction to Optimization"

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral Examination, Standard)

Fachprüfung: oral

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

• Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

depending on topic

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module Description

Module name							
Adv	anced Course	in Optimization	-				
Module no.	Credit Points	Workload	Self-study	Duration	Frequency Every 2.		
04-13- 0113/en	18 CP	540 h	540 h	1 Semester	semester		
Language	of Instruction		Person responsible for the Module				
English			Prof. Dr. rer. nat. Stefan Ulbrich				

1 Courses of the Module

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-13-1301-vu	Advanced Course in Optimization 1	0	Lecture and Exercise	0
04-13-1302-vu	Advanced Course in Optimization 2	0	Lecture and Exercise	0
04-13-1303-vu	Advanced Course in Optimization 3	0	Lecture and Exercise	0
04-13-1304-vu	Advanced Course in Optimization 4	0	Lecture and Exercise	0
04-13-1305-vu	Advanced Course in Optimization 5	0	Lecture and Exercise	0
04-13-1306-vu	Advanced Course in Optimization 6	0	Lecture and Exercise	0

2 Study Content

The topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (opt)" to the extent of 8+4 contact hours per week (2x(4+2) or 1x(4+2)+2x(2+1) or 4x(2+1)). Typical topics include:

nonlinear optimization; discrete optimization

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of optimization

- have an overview of the relations of these branches with each other and their place within the overall context of optimization
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

Requirements for Participation
Passing "Introduction to Optimization"

Form of Examination
Final Module Examination:

• Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)

Fachprüfung: oral

Requirements on the Award of Credit Points
Passing the Fachprüfung

Grading
Final Module Examination:

Module Examination (Technical Examination, oral Examination, Weight: 100%,

8 Usability of the Module

Standard)

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

5

depending on topic

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Module name							
Advanced Course in Stochastics							
Module no. 04-13- 0115/de	Credit Points 18 CP	Workload 540 h	Self-study 540 h	Duration 1 Semester	Frequency Every 2. semester		
Language German	Language of Instruction Person responsible for the Module						

	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week		
	04-13-1501-vu	Advanced Course in Stochastics 1	0	Lecture and Exercise	0		
	04-13-1502-vu	Advanced Course in Stochastics 2	0	Lecture and Exercise	0		
	04-13-1503-vu	Advanced Course in Stochastics 3	0	Lecture and Exercise	0		
	04-13-1504-vu	Advanced Course in Stochastics 4	0	Lecture and Exercise	0		
	04-13-1505-vu	Advanced Course in Stochastics 5	0	Lecture and Exercise	0		
	04-13-1506-vu	Advanced Course in Stochastics 6	0	Lecture and Exercise	0		
	topics of courses with comment "recommended: Mathematics: Master (sto)" to the extended of 18-20 CP (2x9 or 1x9+2x5 or 4x5). Typical topics include: mathematical statistics, curve estimation, stochastic processes, stochastic (partial) differential equations						
3	Learning Outcomes Students - understand the fundamental principles, notions and methos of the topics chosen - are able to apply these to typical problems - have an advanced understanding of several branches of stochastics - have an overview of the relations of these branches with each other and their place within the overall context of stochastics - are able to independently deepen their knowledge in these areas and do guided work on						
	Students - understand t - are able to ap - have an adva - have an over within the ove - are able to in	he fundamental principles, not pply these to typical problems inced understanding of several view of the relations of these brall context of stochastics	branches of stochast branches with each of wledge in these area	stics other and their	place		
4	Students - understand t - are able to ap - have an adva - have an over within the ove - are able to in research quest	he fundamental principles, not oply these to typical problems anced understanding of several view of the relations of these brall context of stochastics adependently deepen their knowions in some of these branches for Participation	branches of stochast branches with each of wledge in these area	stics other and their	place		
	Students - understand to - are able to apulate an advalue an over within the over are able to intresearch quest Requirements Passing "Probate Form of Example of Exa	he fundamental principles, not oply these to typical problems anced understanding of several view of the relations of these brall context of stochastics adependently deepen their knowions in some of these branches for Participation ability Theory"	branches of stochast branches with each of wledge in these areas	stics other and their as and do guid	place ed work on		
4	Students - understand to - are able to apulate an advalue an over within the over are able to intresearch quest Requirements Passing "Probate Form of Example of Exa	he fundamental principles, not oply these to typical problems anced understanding of several view of the relations of these brall context of stochastics adependently deepen their knowions in some of these branches of these branches of the practicipation ability Theory" Inination Examination:	branches of stochast branches with each of wledge in these areas	stics other and their as and do guid	place ed work on		
4	Students - understand t - are able to ap - have an adva - have an over within the ove - are able to in research quest Requirements Passing "Proba Form of Exam Final Module 1 Modul Fachprüfung:	the fundamental principles, not oply these to typical problems anced understanding of several view of the relations of these brall context of stochastics adependently deepen their knowions in some of these branches for Participation ability Theory" Inination Examination: The Examination (Technical Examples on the Award of Credit Points of these to typical problems on the Award of Credit Points on the Award of Credit Points of the Award of Credit Poi	branches of stochast branches with each of wledge in these areas s	stics other and their as and do guid	place ed work on		

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M.Sc. Mathematik, M.Sc. Mathematics

9 Literature

Beispielhaft seien genannt:

Pestmann: Mathematical Statistics

Karatzas, Shreve: Brownian Motion and Stochastic Calculus

Bain, Crisone: Fondamentals of Stochastic Filtering

Da Brato, Zabczyk: Stochastic Equation in finite Arguments

Györfi, Kohler, Krzyzak, Walk: A distribution-free theory of nonparametric regression.

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Mod	dule na	me								
	Adv	anced (Course	in Stochastics						
Module no. Credit 04-13- 0115/en		Points 18 CP	Workload 540 h	•		Duration 1 Semester		Frequency Every 6. semester		
Lan	guage (of Instr	uction		Pers	son respons	ible for	the M	odule	
Eng	lish				Prof	Dr. rer. na	t. Micha	el Kohl	ler	
1	Course	es of the	e Modu	le						
	Course no.		Cours	se name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-13-1	1501-vu	Advance 1	Advanced Course in Stochas		0		Lectur Exerci		0
	04-13-1	1502-vu	Advanced Course in Stochasti 2		stics	0		Lecture and Exercise		0
	04-13-1503-vu		Advanced Course in Stochastic		stics	0		Lecture and 0 Exercise		0
	04-13-1	1504-vu	Advance 4	ed Course in Stocha	stics	0		Lectur Exerci		0
	04-13-1	1505-vu	Advance 5	ed Course in Stocha	stics	0		Lectur Exerci		0

	Ι .		•		
	04-13-1506-vu	Advanced Course in Stochastics 6	0	Lecture and Exercise	0
2	topics of course of 8+4 contact topics include:	agreed upon between student es with comment "recommend hours per week (2x(4+2) or statistics, curve estimation, sto	ed: Mathematics: Ma 1x(4+2)+2x(2+1)	aster (sto)" to or $4x(2+1)$).	the extent Typical
3	 are able to ap have an advant have an overwithin the o	ne fundamental principles, not oply these to typical problems need understanding of several view of the relations of these brall context of stochastics dependently deepen their knowns in some of these branche	branches of stochast branches with each of wledge in these area	tics ther and their	place
4	Requirements Passing "Proba	for Participation bility Theory"			
5		Examination: e Examination (Technical Examination)	mination, oral Exami	ination, Durat	ion 45
6	Requirements Passing the Fac	on the Award of Credit Poin chprüfung	nts		
7	Grading Final Module E Module Standar	e Examination (Technical Exa	mination, oral Exami	ination, Weigl	nt: 100%,
8	Usability of th M.Sc. Mathema	e Module atik, M.Sc. Mathematics			
9	Karatzas, Shrev Bain, Crisone: Da Brato, Zabo	en genannt: hematical Statistics ve: Brownian Motion and Stoc Fondamentals of Stochastic Fi zyk: Stochastic Equation in fir Krzyzak, Walk: A distribution	ltering nite Arguments	arametric regr	ession.

10 Comment

Students acquire the agreed upon contents and skills independently, for example by attending suitable courses or b bookwork. The single topics of this course are not examined speparately but in one all-encompassing exam.

Mod	lule na	me								
			N/1 = 4 l= = .		.4					
Mod no. 04-1 013	-13- 5 CP 1			Self	Self-study Du		Duration 1 Semester		e ncy L.	
		of Instrud Englis				son respons liendekan*ii				
1		es of the		le	beac	ilendekan n	ir des rav	ciibere	10113 04	
	Course			e name		Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0)203-se	Semina: Master	r in Mathematics (al	g),	0		Semin	ar	2
2	Study Content depending on topic									
3	Studen - give a - learn - engag	advanc	to and writ ed-level ofession	ten presentation o mathematical ma al discussions abou	terial	on their ow	'n		_	
4	_			rticipation ling on topic						
5		of Examir Examir	nation:	e] (Study Examina	ation	Presentatio	on Pass	ed / N	ot Passe	d)
		nleistun	g: Oral	presentation, writt	en ez					

6	Requirements on the Award of Credit Points
	Passing the Studienleistung
7	Grading Course Examination: • [04-00-0203-se] (Study Examination, Presentation, Weight: 100%, Passed / Not Passed)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment recommended: Mathematics: Master (alg)

Mod	lule na	me								
	Seminar in Mathematics (ana), Master									
no. 04-1	Module no. Credit Points Workload 04-13- 5 CP 150 h		Self-study 120 h		Duration 1 Semester		Frequency Every 2. semester			
Language of Instruction Person responsible for the Module										
German and English Studiendekan*in des Fachbereichs 04										
1	Course	Courses of the Module								
	Course no. Course name		e name	Workload (CP)		Form of Teaching		Contact Hours per Week		
	04-00-0)204-se	Semina: Master	r in Mathematics (ai	na),	0		Semin	ar	2
2	Study	Conten	t							
	depend	ling on	topic							
3	Learni	ng Outo	comes							
	Studen	its learn	to							
	•			ten presentation o				ematio	cal topic	2
				mathematical ma						
	- engag	ge in pro	ofession	al discussions abou	it the	content and	d presen	tation	of a	

	mathematical talk
4	Requirements for Participation recommended: depending on topic
5	Form of Examination Course Examination: • [04-00-0204-se] (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Course Examination: • [04-00-0204-se] (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment recommended: Mathematics: Master (ana)

Mod	Module name										
	Sem	inar in	Mather	matics (ge	o), Ma	ster					
		Points 5 CP	Workload	150 h	3		Duration 1 Semester		Frequency Every 2. semester		
	0	o f Instru d Englisi					on respons iendekan*ii				
1	Course	es of the	e Modul	le		•					
	Course	e no.	Course	e name			Workload	(CP)	Form Teac		Contact Hours per Week

	04-00-0205-se	Seminar in Mathematics (geo), Master	0	Seminar	2					
2	Study Conten depending on									
3	Learning Outcomes Students learn to - give an oral and written presentation of an advanced-level mathematical topic - learn advanced-level mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk									
4	Requirements for Participation recommended: depending on topic									
5	Form of Examination Course Examination: • [04-00-0205-se] (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)									
6	Requirements Passing the Stu	on the Award of Credit Poin	its							
7	Grading Course Examination: • [04-00-0205-se] (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)									
8	Usability of the M.Sc. Mathem	ne Module atik, M.Sc. Mathematics								
9	Literature depending on	topic								
10	Comment recommended	: Mathematics: Master (geo)								

Module name							
Sem	inar in Mathe	matics (log), Mas	ster				
Module	Credit Points	Workload	Self-study	Duration	Frequency		

no. 04-1			5 CP	150 h		120 h	1 Semes	1 Semester Every 2. semester			
Geri	guage o	l Englis	h		Person responsible for the Module Studiendekan*in des Fachbereichs 04						
1	Course	s of the	e Modul	e		Ť		T			
	Course	e no.	Course	e name	Workload (CP) Form Teac			_	Contact Hours per Week		
	04-00-0)206-se	Seminar Master	in Mathematics (lo	g),	0		Semin	ar	2	
2	Study Content depending on topic										
3	Learning Outcomes Students learn to - give an oral and written presentation of an advanced-level mathematical topic - learn advanced-level mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk										
4	_			ticipation ling on topic							
5	Course • Studier	Examir [04-00 nleistun)-0206-s g: Oral p	e] (Study Examin presentation, write nning of the semin	ten e	_					
6	_		on the adienleis	Award of Credit tung	Poin	its					
7	Grading Course Examination: • [04-00-0206-se] (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)										
8		•	ne Modu atik, M.S	le Sc. Mathematics							
9	Literat depend	ure ling on	topic								

10 Comment

recommended: Mathematics: Master (log)

Mod	lule na	me								
	Sem	inar in	Mathei	matics (num), Ma	astei	r				
Mod no. 04-1 014:	-13- 5 CP		Workload 150 h	Self-study		Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German and English						son respons liendekan*ii				
1	Course	es of the	e Modu	le						
	Course no. Course name					Workload	(CP)	Form Teac	_	Contact Hours per Week
	04-00-0207-se Seminar in Mathematics (num), 0 Seminar Master							2		
2										
3	Studen - give a - learn - engag	advanc	to and writ ed-level ofession	ten presentation o mathematical mat al discussions abou	terial	on their ow	'n		_	
4	_			rticipation ling on topic						
5	Form of Examination Course Examination: • [04-00-0207-se] (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)									
6	-		on the	Award of Credit	Poin	ts				

7	Grading Course Examination: • [04-00-0207-se] (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module
	M.Sc. Mathematik, M.Sc. Mathematics
9	Literature
	depending on topic
10	Comment
	recommended: Mathematics: Master (num)

Mod	lule na	me								
	Seminar in Mathematics (opt), Master									
Mod no.		Credit Points		Workload Self-		-study Duration		Freque		•
04-1 014	-		5 CP	150 h		120 h	1 Semes	ster	Every 2. semester	
		of Instru d Englisi				son respons diendekan*ii				
1	Course	s of the	e Modul	le						
	Course no. Course name				Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0	208-se	Semina: Master	r in Mathematics (o	pt),	0		Seminar		2
2	•	Contenting on								
3	Learning Outcomes Students learn to - give an oral and written presentation of an advanced-level mathematical topic - learn advanced-level mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk									
4	Requir	ements	for Pa	ticipation						

	recommended: depending on topic
5	Form of Examination Course Examination: • [04-00-0208-se] (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Course Examination: • [04-00-0208-se] (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment recommended: Mathematics: Master (opt)

Mod	Module name										
	Seminar in Mathematics (sto), Master										
Module no. 04-13- 0145		Credit	Points 5 CP	Workload	150 h			Duration 1 Semester		Frequency Every 2. semester	
Ger	guage o	d Englis	h	1-		Person responsible for the Module Studiendekan*in des Fachbereichs 04					
1	Course no. Course no.		<u> </u>	rse name			Workload	(CP)	Form of Teaching		Contact Hours per Week
	04-00-0)209-se	Semina Master	r in Mathema	atics (st	o),	0		Semin	ar	2

2	Study Content depending on topic
3	Learning Outcomes Students learn to - give an oral and written presentation of an advanced-level mathematical topic - learn advanced-level mathematical material on their own - engage in professional discussions about the content and presentation of a mathematical talk
4	Requirements for Participation recommended: depending on topic
5	Form of Examination Course Examination: • [04-00-0209-se] (Study Examination, Special Form, Passed / Not Passed) Studienleistung: Oral presentation, written expose where appropriate (Details will be announced at the beginning of the seminar)
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Course Examination: • [04-00-0209-se] (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module M.Sc. Mathematik, M.Sc. Mathematics
9	Literature depending on topic
10	Comment recommended: Mathematics: Master (sto)

Module na	Module name						
Adv	anced Course	Numerical Analy	sis Data Science	e			
Module no. 04-13-	Credit Points 18 CP		Self-study 540 h	Duration 1 Semester	Frequency Every semester		

020	9/en							
Lan	guage of Instri	uction			_		the Module	!
Eng	T .			Prof	Dr. rer. na	t. Jan Gi	esselmann	
1	Courses of the	e Modul	le		ı			
	Course no. Course name		e name		Workload (CP)		Form of Teaching	Contact Hours per Week
	04-13-2091-vu		ed Course Numerica Data Science 1	1	0		Lecture and Exercise	0
	04-13-2092-vu Advanced Course Numeri Analysis Data Science 2				0		Lecture and Exercise	0
	04-13-2093-vu Advanced Course Numeric Analysis Data Science 3				0		Lecture and Exercise	0
	04-13-2094-vu Advanced Course Numeric Analysis Data Science 4				0		Lecture and Exercise	0
	04-13-2095-vu Advanced Course Numeric Analysis Data Science 5				0		Lecture and Exercise	0
	04-13-2096-vu	u Advanced Course Numerical O Analysis Data Science 6					Lecture and Exercise	0
			ics include numer fficient methods fo					
3	covered in the understanding understand ho numerical ana	tnow and lecture of sever the tool lecture and lecture	d understand the or and they are able ral areas of numer opics are related and scientific computes the research quest	to entical and ho	nploy them. analysis and ow they fit ir They are abl	The stude scientification the golden the golden the golden to independent of the science of the	dents have a c computing eneral conte ependently o	in-depth . They ext of extend their
4	Requirements Recommended		rticipation rik gewöhnlicher l	Differ	entialgleich	ungen		
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)							
6	Requirements Passing the Fa		Award of Credit	Poin	ts			

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

8 Usability of the Module

M. Sc. Mathematics, Mathematics in Data Science

9 Literature

M. Asch, M. Bocquet, M. Nodet; Data Assimilation: Methods, Algorithms and Applications, SIAM 2016

S. Brenner, R. Scott: Mathematical Theory of Finite Element Methods, Texts in Applied Mathematics, Vol. 15, Springer, 2008

W. Hackbusch, Iterative Solution of Large Sparse Systems of Equations, 2nd ed. 2016, Applied Mathematical Sciences Vol. 95, Springer International Publishing, 2016 S. Larsson, V. Thomée: Partial Differential Equations with Numerical Methods.

Texts in Applied Mathematics, Vol. 45, Springer 2003.

K. Law, A. Stuart, Konstantinos Zygalakis; Data Assimilation: A mathematical introduction, Springer, 2015

G. J. Lord, C. E. Powell, and T. Shardlow. An Introduction to Computational Stochastic PDEs. Cambridge University Press, 2014.

10 Comment

Die vereinbarten Inhalte und Kompetenzen erwirbt der/die Studierende eigenständig, z.B. durch Teilnahme an Lehrveranstaltungen entsprechenden Inhalts oder im Selbststudium. Die einzelnen Inhalte des Vertiefungsmoduls Numerik und Wissenschaftliches Rechnen werden nicht separat, sondern in einem alle Inhalte umfassenden Prüfungsereignis geprüft

Mod	odule name									
	Advanced Course Analysis Data Science									
Mod no. 04-1 021		Credit	Points 18 CP	Workload 540 h		- study 540 h	Duratio 1 Semes		Freque Every s	ncy emester
Eng	lish	of Instru				Person responsible for the Module Prof. Dr. rer. nat. Moritz Egert				
Course no. Course name				Workload	(CP)	Form Teac		Contact Hours per Week		
	04-13-2	2111-vu	Advance	ed Course Analysis I	Oata	0		Lectur	e and	0

	Science 1		Exercise	
04-13-2112-vu	Advanced Course Analysis Data Science 2	0	Lecture and Exercise	0
04-13-2113-vu	Advanced Course Analysis Data Science 3	0	Lecture and Exercise	0
04-13-2114-vu	Advanced Course Analysis Data Science 4	0	Lecture and Exercise	0
04-13-2115-vu	Advanced Course Analysis Data Science 5	0	Lecture and Exercise	0
04-13-2116-vu	Advanced Course Analysis Data Science 6	0	Lecture and Exercise	0

2 Study Content

he topics are agreed upon between student and examiner. Normally these consist of topics of courses with comment "recommended: Mathematics: Master (ana)" to the extent of of 8+4 contact hours per week (2x(4+2) or 1x(4+2)+2x(2+1) or 4x(2+1)) Typical topics include:

Investigation of existence, uniqueness and regularity of linear and nonlinear partial differential equations with modern methods, applications in fluid mechanics using data science driven methods.

3 Learning Outcomes

Students

- understand the fundamental principles, notions and methos of the topics chosen
- are able to apply these to typical problems
- have an advanced understanding of several branches of analysis
- have an overview of the relations of these branches with each other and their place within the overall context of analysis and data science
- are able to independently deepen their knowledge in these areas and do guided work on research questions in some of these branches

4 Requirements for Participation

depending on the topics covered

5 Form of Examination

Final Module Examination:

Module Examination (Technical Examination, oral Examination, Duration 40 min, Standard)

6 Requirements on the Award of Credit Points

Passing the Fachprüfung

7 Grading

Final Module Examination:

 Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)

Usability of the Module M. Sc. Mathematics, Mathematics in Data Science Literature L.C. Evans: Partial Differential Equations (AMS) T.-P. Tsai: Lectures on Navier-Stokes Equations (AMS) M. Tucsnak, G. Weiss: Observation and Control for Operator Semigroups (Springer) S. Reich, C. Cotter: Probabilistic Forecasting and Bayesian Data Assimilation (Cambrige University Press) Moukalled, F., Mangani, L., amp; Darwish, M. (2016). The finite volume method. In The finite volume method in computational fluid dynamics (pp. 103-135). Springer, Cham. Maric, Tomislav, Jens Hopken, and Kyle Mooney. "The OpenFOAM technology primer." (2014). Karniadakis, G. E., Kevrekidis, I. G., Lu, L., Perdikaris, P., Wang, S., amp; Yang, L. (2021). Physics-informed machine learning. Nature Reviews Physics, 3(6), 422-440. 10 Comment

Mod	lule naı	me									
	Adva	anced (Course	Optimization Da	ıta So	ience					
Module no. 04-13-		Credit Points		Workload 540 h	Self-study		Duration 1 Semester		Frequ Every	ency semester	
	3/en		10 01	0 10 11		0 10 11	2 0011	00101	Livery	Semester	
Language of Instruction English						on respons . Dr. rer. nat					
1	Courses of the Module										
	Course	e no.	Course name			Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-13-2	2131-vu	Advance Data Sc	ed Course Optimization ence 1		0		Lecture and Exercise		0	
	04-13-2132-vu Advanced Course Optimiza Data Science 2		tion	on 0		Lectur	re and ise	0			
	04-13-2133-vu Advanced Course Optimiza Data Science 3		tion	n 0		Lecture and Exercise		0			
	04-13-2134-vu Advanced Course Optimiza Data Science 4		tion	n 0		Lecture and Exercise		0			
	04-13-2	135-vu	Advance	ed Course Optimiza	tion	0		Lectu	re and	0	

				•					
		Data Science 5		Exercise					
	04-13-2136-vu	Advanced Course Optimization Data Science 6	0	Lecture and Exercise	0				
2	Study Conten			Exercise					
_	The topics are consist of topic Master (Optim (2x(4+2) or 1 Typical topics Methods: exact with and without topics are consistent of the consistency of the consistenc	agreed upon between student cs of courses with comment "redization Data Science)" to the ex $(4+2)+2x(2+1)$ or $4x(2+1)$ include: Theory: conditions for talgorithms for integer linear	commended: Mathe extent of 8+4 contact. r optimality, polyhed programs; methods	ematics: et hours per wo dral combinato	orics.				
3	Learning Outcomes								
	After having attended the module, students will have a good command of the theoretical fundamentals of discrete and nonlinear optimization. The students are additionally able to solve modeling problems and to analyze and apply relevant algorithms.								
4	Requirements for Participation								
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)								
6	Requirements Passing the Fa	on the Award of Credit Poin	nts						
7	Grading Final Module I Modul Standa	e Examination (Technical Exa	mination, oral Exam	ination, Weigl	ht: 100%,				
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science								
9	Literature Geiger, Kanzow: Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben Nemhauser, Wolsey: Integer and Combinatorial Optimization Nocedial, Wright: Numerical Optimization Schrijver: Theory of Linear and Integer Programming								
10	Comment								

Mod	lule na	me								
	Adva	anced (Course	Stochastics Data	Scie	ence				
no. 04-1	Module no. Credit 04-13- 0215/en		Points 18 CP	Workload 540 h	Self-study 540 l		Duration 1 Semester		Frequency Every semester	
Lang Engl		of Instru	uction			son respons f. Dr. rer. nat				
1	Course	es of the	e Modu	le						
			Cours	e name		Workload (CP)		Form Teac	-	Contact Hours per Week
	04-13-2151-vu Advand Data S				es	0		Lectur Exerci	0 0.110	0
	04-13-2	2152-vu	Advanc Data Sc	ed Course Stochastic ience 2	es .	0		Lectur Exerci		0
	04-13-2153-vu Advano Data S		Advanc Data Sc			0		Lecture and Exercise		0
	04-13-2154-vu Advand Data S		Advanc Data Sc					Lecture and Exercise		0
	04-13-2	2155-vu	Advanc Data Sc			0		Lectur Exerci		0
	04-13-2	2156-vu	Advanc Data Sc	ed Course Stochastic ience 6	es	0		Lectur Exerci		0
2	The co		this mo	odul consists of the cal theory for Dee	_		wo mod	lules "I	Mathem	atical
3	Learning Outcomes The students know and understand the concepts, methods and results of the modules mentioned above. They have a deep understanding of Mathematical Statistics and Deep Learning and are able to learn new knowledge in this field by themselves.									
4	Requirements for Participation									
5	Form of Examination Final Module Examination: • Module Examination (Technical Examination, oral Examination, Duration 45 min, Standard)									

6	Requirements on the Award of Credit Points Passing the Fachprüfung
7	Grading Final Module Examination: • Module Examination (Technical Examination, oral Examination, Weight: 100%, Standard)
8	Usability of the Module M. Sc. Mathematics, Mathematics in Data Science
9	Literature Lehmann, Romano: Testing Statistical Hypotheses. Devroye, Lugosi: Combinatorial methods in density estimation Goodfellow, Bengio, Courville: Deep Learning. Györfi, Kohler, Krzyzak, Walk: A distribution - free theory of nonparametric regression
10	Comment

Mod	lule na	me								
	Matl	hemati	cs as Co	ommon Languag	je in	Science				
no. 04-1	Module no. Credit F 04-14- 0001/de		Points 5 CP	Workload 150 h	Self-study 105 h		Duration 1 Semester		Frequency Every 2. semester	
Lan	guage (of Instru	ıction		Pers	son respons	ible for	the M	odule	
Gen	German				Prof	Dr. rer. na	t. Burkha	ırd Kü	mmerer	
1	Courses of the Module									
	Course no. Course		e name		Workload (CP)		CP) Form of Teaching		Contact Hours per Week	
	04-14-0)001-vu		nartics as Common ge in Science		0	Lecture and Exercise		3	
2	Study Content In an interplay between multidisciplinary relevant mathematical contents and its reflection we convey the significance and functionality of mathematics as the common language of natural sciences. Mathematical Contents: • Numbers, in particular real numbers									

- Continuity
- Some special functions
- Approximation and power series
- Logarithms, pH-values, bits, and entropy
- Probability
- Law of large numbers, limit theorems, and significance of data records
- Derivative and differential
- Modelling with differential equations
- Vector fields
- Linearity and superposition
- Many dimensions

Mathematical Reflections:

- All is number: blessing and curse of quantifying
- On the use of formulas: What you put into it and what you get out.
- Mathematical models of reality: capabilities and limitations
- On the truth of mathematics
- Historical remarks on mathematics as a language for natural sciences
- Mathematics is a very special language: Axioms, definitions, and proofs inside and outside of mathematics
- The abstractness of mathematics as a condition for its universal applicability

Depending on the target group, the support classes address students of mathematics, concentrating, amongst other things, on specialist aspects of mathematics; students who do not study mathematics are tutored in the fundamentals of handling mathematical language in its stead.

3 Learning Outcomes

Students are able to

• apply fundamental mathematical methods in natural sciences

- read and to understand mathematical texts and to interpret mathematical formulas
- apply the addressed mathematical methods successfully
- mathematize scientific issues and to describe quantitative relations by formulas
- compare and to critically question mathematical models
- see relations between various naturals sciences
- support their school lessons by interdisciplinary cross linking
- state the role of mathematics for natural sciences
- explain the relation between abstract mathematics and concrete applications
- resort to important concepts from the history if ideas and from the philosophy of science
- address characteristics of the mathematical language

4 Requirements for Participation

none

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung (Technical Examination): Usually the exam is taken in form of a written test, except when there are only a small number of potential participants. In this case, the exam can be taken in the form of an oral exam. The decision about the form of the exam is taken and communicated during the first two weeks of the lecture, based on the prospective number of students taking the exam.

6 Requirements on the Award of Credit Points

Passing the Fachprüfung (normally the exam is held orally; in case of a large number of participants the exam can be held as a written test)

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, oral / written Examination, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8	Usability of the Module Teaching degrees: Vernetzungsbereich
9	Literature Georg Glaeser: Der mathematische Werkzeugkasten. Anwendungen in Natur und Technik. Springer Spektrum. Tilo Arens et al.: Mathematik. Springer Spektrum.
10	Comment

Mod	lule na	me								
	Proie	ect in M	lathem	atical Consulting	1					
no.	odule c. Credit Points 4-14- 2 CP			Self-study		Duration 1 Semester		Frequency Every 2. semester		
	guage (man	of Instru	action			on respons Dr. rer. na				
1	Course	es of the	e Modu	le						
	Course	Course no. Course name Workload (CP)				Form Teac		Contact Hours per Week		
	04-14-0100-pr Project in Mathematical 0 Project 2 Consulting				2					
2	A grou project proble The co	The entry. The entry. The entry. The entry. The entry.	th-stude ngineer arise w group	nts acts as a mathing students mustithin their project. explores possible rand discusses the	be ac	lvised in the ematical app	treatme	nt of r	nathema	
3	Learning Outcomes Die Studierenden haben gelernt mathematische Fragestellungen in ingenieurwissenschaftlichen Problemen zu erkennen und vorab verschiedenen Lösungswege zu erarbeiten. Sie können sich mit Studierenden anderer Fachrichtungen in deren Fachsprache austauschen und mathematische Vorgehensweisen plausibel begründen.									
4	_			rticipation ear Algebra, Calcu	ılus.	Numerics. S	tochatics	s, and	ADM, ao	dvanced

	knowledge in applied mathematics is desireable
5	Form of Examination Final Module Examination: • Module Examination (Study Examination, Special Form, Passed / Not Passed)
6	Requirements on the Award of Credit Points Passing the Studienleistung
7	Grading Final Module Examination: • Module Examination (Study Examination, Special Form, Weight: 100%, Passed / Not Passed)
8	Usability of the Module MSc. Math: studium generale
9	Literature
10	Comment

Mod	dule nan	ne									
	Found	dation	s of Te	aching and Learı	ning (of Mathem	atics				
Module no. 04-30- 0087		Credit Points 8 CP		Workload 240 h	Self-study 180 h		Duration 1 Semester		Frequency Every 2. semester		
Lan	guage of	f Instru	ıction		Person responsible for the Module						
Ger	man				Prof.	Dr. phil. na	at. Katja	Krüge	r		
1	Courses of the Module										
	Course no. Cours		e name		Workload (CP)		Form Teac		Contact Hours per Week		
			-	ized didactics for raduates		0		Proseminar		0	
	04-00-0179-vu Teachir Mather		Teachin Mathem			0		Lecture and Exercise		4	
2	Study C	Conten	t							•	

Modelle zur Behandlung typischer Unterrichtssituationen, Umgang mit Heterogenität, Aufgabentheorie, Ziele und Inhalte des Mathematikunterrichts mit Begründungen, Wege zum langfristigen Kompetenzaufbau

3 Learning Outcomes

Die Studierenden können unterschiedliche theoretische Konzepte und Gestaltungsmodelle für typische mathematische Lehr- und Lernsituationen in heterogenen Lerngruppen beschreiben und umsetzen, Aufgaben auswählen und gestalten mit einem definierten Kompetenzprofil und sie können die Ziele und Inhalte mathematischer Lernumgebungen begründen

4 Requirements for Participation

Mathematik als gemeinsame Sprache der Naturwissenschaften und Analysis und Lineare Algebra oder vergleichbare Vorkenntnisse (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Standard)
- Module Examination (Study Examination, Special Form, Standard)
- Module Examination (Study Examination, Special Form, Standard)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistungen: In der Vorlesung: Sonderform (In der Regel erfolgreiche Bearbeitung eines Teils der Hausübungen zur Vorlesung und aktive Mitarbeit in den Übungen. Die Anzahl sowie das Bewertungsschema als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben. Im Proseminar aktive Mitarbeit in den Seminarsitzungen, Führen eines E-Portfolios, ein Kurzvortrag und eine darauf bezogene schriftliche Ausarbeitung).

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung; Bestehen der Studienleistungen als Zulassungsvoraussetzung zur Fachprüfung

Erfolgreiche Teilnahme zu 75%* an den Lehrveranstaltungen [04-00-0107-ps / Fachdidaktisches Proseminar; 04-00-0179-vu / Übung zu Lehren und Lernen von Mathematik].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z.B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
 Module Examination (Study Examination, Special Form, Weight: 0%, Standard)
 Module Examination (Study Examination, Special Form, Weight: 0%, Standard)
 Usability of the Module
 Literature

Bruder, R., Hefendehl-Hebeker, L., Schmidt-Thieme, B. Weigand, H.-G. (Hrsg.) (2015). Handbuch der Mathematikdidaktik. Springer Berlin Heidelberg.

Bruder, R., Büchter, A. Leuders, T. (2008). Mathematikunterricht entwickeln. Bausteine für kompetenzorientiertes Unterrichten. Cornelsen Scriptor.
 Comment

Module name											
Mathematisches Seminar (alg), Master, für FB Informatik											
Module no. 04-30- 0139/de		Credit Points 6 CP		Workload 180 h	Self-study 150 h		Duration 1 Semester		Frequency Every 2. semester		
Language of Instruction German Person responsible for the Module											
1	Courses of the Module										
	Course no.		Course	Course name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0)203-se	Semina: Master	r in Mathematics (al	g), 0 Ser			Seminar		2	
2	Study Content special topics of Algebra, Geometry, Functional Analysis										
3	Learning Outcomes Die Studierenden können sich eigenständig anspruchsvolle mathematische Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern und präsentieren, sowie gegebenfalls schriftlich dokumentieren. Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages,										

	führen.
4	Requirements for Participation Vertiefungsmodule nach Angabe
5	Form of Examination Course Examination: • [04-00-0203-se] (Study Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Course Examination: • [04-00-0203-se] (Study Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Vertiefungsbereich (Studienleistung)
9	Literature depending on topic
10	Comment Verantwortlich: Studiendekan

Module name												
Mathematisches Seminar (geo), Master, für FB Informatik												
Module no. 04-30-0141/de		Credit	Points 6 CP	Workload	180 h		study 150 h	Duration 1 Semester		Frequency Every 2. semester		
	Language of Instruction German						Person responsible for the Module					
1	Course	s of the	e Modul	le								
	Course no. Course name				Workload	(CP)	Form Teac	-	Contact Hours per Week			
	04-00-0205-se Seminar in Mathematics (§ Master			ıtics (g∈	eo),	0		Semin	ar	2		

2	Study Content special topics of geometry and approximation
3	Learning Outcomes Die Studierenden können sich eigenständig anspruchsvolle mathematische Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern und präsentieren, sowie gegebenfalls schriftlich dokumentieren. Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages, führen.
4	Requirements for Participation Vertiefungsmodule nach Angabe
5	Form of Examination Course Examination: • [04-00-0205-se] (Study Examination, oral / written Examination, Standard)
6	Requirements on the Award of Credit Points
7	Grading Course Examination: • [04-00-0205-se] (Study Examination, oral / written Examination, Weight: 100%, Standard)
8	Usability of the Module Vertiefungsbereich (Studienleistung)
9	Literature depending on topic
10	Comment Verantwortlich: Studiendekan

Module name										
Mathematisches Seminar (log), Master, für FB Informatik										
Module no.	Credit Points	Workload	Self-study	Duration	Frequency					
04-30- 0142/de	6 CP	180 h	150 h	1 Semester	Every 2. semester					
Language o	of Instruction		Person responsible for the Module							

Ger	man									
1	Courses of the	e Module								
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week					
	04-00-0206-se	Seminar in Mathematics (log Master	g), 0	Seminar	2					
2	Study Content special topics of logic									
3	Learning Outcomes Die Studierenden können sich eigenständig anspruchsvolle mathematische Sachverhalte aneignen und in einem ansprechenden Fachvortrag erläutern und präsentieren, sowie gegebenfalls schriftlich dokumentieren. Sie können eine faire Diskussion über Inhalte und Darstellung des Vortrages, führen.									
4	Requirements for Participation Vertiefungsmodule nach Angabe									
5	Form of Examination Course Examination: • [04-00-0206-se] (Study Examination, oral / written Examination, Standard)									
6	Requirements	s on the Award of Credit I	Points							
7	Grading Course Examination: • [04-00-0206-se] (Study Examination, oral / written Examination, Weight: 100%, Standard)									
8	Usability of th Vertiefungsber	ne Module reich (Studienleistung)								
9	Literature depending on topic									
10	Comment Verantwortlich	n: Studiendekan								

Mod	Module name									
	Intro	ductio	n to Al	gebra and Didac	tics (of Algebra				
Mod no. 04-3 052	lule	Credit Points 8 CP			Self-study		Duration 1 Semester		Frequency Every 2. semester	
	Language of Instruction German					son respons f. Dr. phil. na				
1	Course	es of the	e Modu	le						
			Cours	e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)006-vu	Introdu	ction to Algebra		0		Lectur Exerci	-	3
	04-00-0)039-pj	Subject- in school	-specific project: Alg ols	ebra	0		Project		4
	Elementare Gruppentheorie, Gruppenwirkungen, Ringe, Teilbarkeit, Polynomringe, Moduln. Zahlbereichserweiterungen und Behandlung von Gleichungen und Termen in den beiden Sekundarstufen, Rechnen können, Technologieeinsatz, Teilbarkeitsuntersuchungen; typische Schülerfehler, Aufbau von Grundvorstellungen, Möglichkeiten der Nutzung von Strategien, Prinzipien und Modellen für die Entwicklung eines Spiralcurriculums bis zur Sekundarstufe II.								len beiden ngen; tzung von	
3	Learning Outcomes Die Studierenden verstehen die grundlegenden Begriffe und Methoden der Theorie der Gruppen, Ringe und Moduln. Sie können diese auf typische Fragestellungen anwenden. Die Studierenden erlangen fachliche Sicherheit in schulrelevanten Aspekten der Algebra und Zahlentheorie. beherrschen Darstellungen und Konzepte, um Themengebiete der Algebra in der Schule zu veranschaulichen, sprachsensibel und binnendifferenzierend zu gestalten. praktizieren in den Übungen zahlreiche Beispiele für intelligentes Üben und Begabtenförderung und entwickeln ihre diagnostische Kompetenz									
4	Requirements for Participation Analysis, Lineare Algebra, Grundlagen des Lehrens und Lernens von Mathematik (Teilnahme ohne Nachweis möglich)									
5	Form of Examination									

Final Module Examination:

- Module Examination (Study Examination, Homework, Worksheets, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Duration 45 min, Standard)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)

Studienleistung: Sonderform (In der Vorlesung in der Regel eine erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben. Im Seminar in der Regel aktive Mitarbeit in den Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung;

Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung. Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0039-se Fachdidaktisches Seminar: Algebra in der Schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z.B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Homework, Worksheets, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

S. Lang: Algebra, Addison-Wesley;

N. Jacobson: Basic Algebra 1, Freeman

S. Bosch: Algebra, Springer

Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.

Malle, G. (1993). Didaktische Probleme der elementaren Algebra. Vieweg,

Braunschweig/Wiesbaden.

Gängige Schulbücher

10	Comment

Mod	dule na	me								
	Com	plex A	nalysis	and Didactics of	Ana	ysis				
Module no.		Credit	Points	Workload	Self-	study	Duratio	n	Freque	•
04-3 052	30- 1/de	8 CI		240 h	165 h		1 Semester		Every 2. semester	
Lan	guage (of Instru	action		Person responsible for the Module					
Gen	man an	d Englis	h		Prof. Dr. phil. nat. Katja Krüger					
1	Course	es of the	e Modul	le						
	Course	e no.	Course	rse name		Workload	(CP)	Forn Teac	_	Contact Hours

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-00-0159-se	Seminar for subject-specific didactics: Analysis in schools	0	Seminar	2
04-00-0225-vu	Complex Analysis	0	Lecture and Exercise	3

2 Study Content

Cauchy-Riemann Differentialgleichungen, Kurvenintegrale, Cauchy'scher Integralsatz, Cauchy'sche Integralformel, Potenzreihen, Satz von Liouville und Hauptsatz der Algebra, Umlaufzahl Laurentreihen und isolierte Singularitäten, Residuensatz Funktionspropädeutik, Funktionsuntersuchungen, Lokale Änderungsrate und Grenzwertbegriff, Riemannscher Integralbegriff, Anwendungen der Infinitisemalrechnung in der Schule, Fehlvorstellungen von Schülern; Oberstufencurriculum, Unterrichtsgestaltung, Technologieeinsatz

3 Learning Outcomes

Nach dem Besuch des Moduls

- sind sie mit den Cauchy-Riemannschen DGL vertraut
- können sie Kurvenintegrale analysieren und berechnen
- sind sie mit dem Cauchyschen Integralsatz und der Cauchyschen Integralformel vertraut und können deren Implikationen aufzeigen
- sind sie mit der Bedeutung der Potenzreihen in der Funktionen-theorie vertraut
- können sie den Satz von Liouville und den Hauptsatz der Algebra erklären
- können sie Laurentreihen analysieren
- können sie isolierte Singularitäten anhand konkreter Beispiele erklären
- -sind mit dem Residuensatz und dessen Implikationen vertraut

Die Studierenden...

...erlangen fachliche Sicherheit in besonders schulrelevanten Aspekten der Analysis und

können verschiedene Zugänge und Schwerpunktsetzungen gegeneinander abwägen.

- ...beherrschen Darstellungen und Konzepte, um Themengebiete der Analysis in der Schule zu veranschaulichen auch mit Technologieeinsatz.
- ...praktizieren in den Übungen zahlreiche Beispiele für intelligentes Üben, Diagnose und Förderung.

4 Requirements for Participation

Analysis, Lineare Algebra, Grundlagen des Lehrens und Lernens von Mathematik (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Duration 45 min, Standard)
- Module Examination (Study Examination, Homework, Worksheets, Passed / Not Passed)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)

Studienleistung: Sonderform (In der Vorlesung in der Regel eine erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben. Im Seminar in der Regel aktive Mitarbeit in den Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung;

Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0159-se Fachdidaktisches Seminar: Analysis in der Schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z.B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Homework, Worksheets, Weight: 0%, Passed / Not Passed)

8	Usability of the Module
	Mathematik: Lehramt
9	Literature Freitag: Funktionentheorie I, Springer. Remmert: Funktionentheorie I Conway: Functions of one complex variable, Springer Tietze, UP., Klika,M., Wolpers, HH.: Mathematikunterricht in der SII, Bd. 1, Fachdidaktische Grundfragen, Didaktik der Analysis. Vieweg 2000, Büchter, A., Henn, HW.: Elementare Analysis: Von der Anschauung zur Theorie. Spektrum 2010. Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Kratz, Henrik (2011). Wege zu einem kompetenzorientierten Mathematikunterricht – Ein Studien- und Praxisbuch für die Sekundarstufe. Kallmeyer – Klett, Seelze Gängige Schulbücher
10	Comment

Mod	Module name									
	Ordi	nary Di	fferent	ial Equations an	d Me	edia-Based	Teachir	ng and	d Learn	ing
Module no. 04-30-0522/de		Credit	Points Workload 240 h		3		Duration 1 Semester		Frequency Every 2. semester	
Lan	Language of Instruction					on respons	ible for	the M	odule	
Ger	German					. Dr. phil. na	at. Katja	Krüge	r	
1	Course	es of the	e Modu	le						
	Course no. Cours			e name		Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0)054-vu	Ordinar	y Differential Equat	ions 0		Lecture and Exercise		3	
	didactic			es: New media in		0		Seminar		2
2	Study Content Trennung der Variablen, Sätze von Picard-Lindelöf und Peano, lokale und globale Theorie, lineare Systeme erster und höherer Ordnung, Variation-der-Konstanten-Formel, Prinzip linearisierter Stabilität, Lyapunov-Stabilität. Technische Möglichkeiten, didaktische Konzepte und Anwendungsbeispiele zu Tabellenkalkulationsprogrammen, dynamischer Geometriesoftware, Computer-Algebra- Systemen, Programmierung und didaktischer Hardware									

3 Learning Outcomes

Qualifikationsziele / Lernergebnisse

Nach dem Besuch des Moduls

- können sie die Methode der Trennung der Variablen
- sind sie mit den Sätzen von Picard-Lindelöf und Peano vertraut
- sind sie mit der lokalen und globalen Existenztheorie gewöhnlicher Differentialgleichungen vertraut
- können sie lineare Systeme erster und höherer Ordnung analysieren
- können sie die Variation der konstanten Formel entwickeln
- können sie das Prinzip linearisierter Stabilität formulieren und anwenden
- sollten sie den Begriff der Lyapunov Stabilität erklären und auf konkrete Beispiele anwenden können.

Die Studierenden...

- ...erlangen Grundkenntnisse in den gängigsten Mathematikprogramm-kategorien, im Umgang mit Taschenrechnern, Tablets und interaktiven Whiteboards und im Programmieren.
- ...können Medienanwendungen mit unterschiedlichen didaktischen Konzepten begründen und entwickeln.

4 Requirements for Participation

Analysis und Lineare Algebra und Grundlagen des Lehrens und Lernens von Mathematik, Mediendidaktik (Vernetzungsbereich). (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Duration 45 min, Standard)
- Module Examination (Study Examination, Homework, Worksheets, Passed / Not Passed)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)

Studienleistung: Sonderform (In der Vorlesung in der Regel eine erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben. Im Seminar in der Regel aktive Mitarbeit in den Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung;

Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung. Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung (04-00-0249-se / Fachdidaktisches Seminar: Medien in der Schule).

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z.B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Homework, Worksheets, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

H. Amann: Gewöhnliche Differentialgleichungen, de Gruyter

W.Walther: gew. DGL, Springer

Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Barzel, B., Hußmann, S., Leuders, T. (2005): Computer, Internet Co. im Mathematik-

Unterricht. Cornelsen Verlag Scriptor.

Artikel aus "mathematik lehren" und gängige Schulbücher

10 Comment

Mod	Module name											
	Elementary Number Theory and Didactics of Algebra											
Module no. 04-30- 0523/de		Credit	Points 8 CP	Workload	240 h		study 135 h	Duratio 1 Semes		Frequent Every 4. semeste		
		of Instru	ıction			Person responsible for the Module						
Ger	man					Prof. Dr. phil. nat. Katja Krüger						
1	Course	es of the	e Modul	le								
	Course no. Course		e name			Workload	(CP)	Form Teac	_	Contact Hours per Week		

04-00-0039-pj Subject-specific project: Algebrin schools		0	Project	4
04-10-0389-vu	Elementary Number Theory (Lehramt)	•	Lecture and Exercise	3

2 Study Content

Primzahlen, Primfaktorzerlegung, Kongruenzen, Fermats kleiner Satz, RSA-Kryptosystem, Legendre-Symbol, quadratische Reziprozität.

Ausblick in Gaußsche ganze Zahlen, den Dirichletschen Primzahlsatz oder das Fermatsche Problem.

Zahlbereichserweiterungen und Behandlung von Gleichungen und Termen in den beiden Sekundarstufen, Rechnen können, Technologieeinsatz, Teilbarkeitsuntersuchungen; typische Schülerfehler, Aufbau von Grundvorstellungen, Möglichkeiten der Nutzung von Strategien, Prinzipien und Modellen für die Entwicklung eines Spiralcurriculums bis zur Oberstufe.

3 Learning Outcomes

Einführung in die elementare Zahlentheorie und Behandlung einiger klassischer Probleme

Die Studierenden...

- ...erlangen fachliche Sicherheit in schulrelevanten Aspekten der Algebra und Zahlentheorie.
- ...beherrschen Darstellungen und Konzepte, um Themengebiete der Algebra in der Schule zu veranschaulichen, sprachsensibel und binnendifferenzierend zu gestalten.
- ...können anhand der in den Übungen praktizierten zahlreichen Beispiele Kriterien für intelligentes Üben und Begabtenförderung erläutern und entwickeln ihre diagnostische Kompetenz

4 Requirements for Participation

Lineare Algebra und Grundlagen des Lehrens und Lernens von Mathematik (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Homework, Worksheets, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Duration 45 min, Standard)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistung: Sonderform (In der Vorlesung in der Regel eine erfolgreiche Bearbeitung eines Teils der Hausübungen. Die Anzahl sowie das Bewertungsschema der Hausübungen als Studienleistung wird während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben. Im Seminar in der Regel aktive Mitarbeit in den Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung:

Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung. Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung (04-00-0039-se / Fachdidaktisches Seminar: Algebra in der Schule).

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z.B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Homework, Worksheets, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

A. Beck, M.N. Bleicher, D.W. Crowe: Excursions into Mathematics. Worth Publishers, Inc.1969.

B.M.Steward: Theory of Numbers 2nd ed. The Macmillian Company. New York 1964 Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Malle, G. (1993). Didaktische Probleme der elementaren Algebra. Vieweg, Braunschweig/Wiesbaden.

Gängige Schulbücher

10 Comment

Module na	Module name										
Didactics of Algebra											
Module no. 04-30- 0530/de	Credit Points 3 CP	Workload	90 h	Self-study 60 h	Duration 1 Semester	Frequency Every 2. semester					
-	of Instruction			Person respons Prof. Dr. phil. na							

1	Courses of the Module										
	Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week						
	04-00-0039-se	Seminar for subject-specific didactics: Algebra in schools	0	Seminar	2						

2 Study Content

Zahlbereichserweiterungen und Behandlung von Gleichungen und Termen in den beiden Sekundarstufen, Rechnenkönnen, Technologieeinsatz, Teilbarkeitsuntersuchungen; typische Schülerfehler, Aufbau von Grundvorstellungen, Möglichkeiten der Nutzung von Strategien, Prinzipien und Modellen für die Entwicklung eines Spiralcurriculums bis zur Sekundarstufe II.

3 Learning Outcomes

Die Studierenden...

- ...erlangen fachliche Sicherheit in schulrelevanten Aspekten der Algebra und Zahlentheorie.
- ...beherrschen Darstellungen und Konzepte, um Themengebiete der Algebra in der Schule zu veranschaulichen, sprachsensibel und binnendifferenzierend zu gestalten.
-können anhand der in den Übungen praktizierten zahlreichen Beispiele Kriterien für intelligentes Üben erläutern und entwickeln ihre diagnostische Kompetenz

4 Requirements for Participation

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Duration 15 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistung: Sonderform (Im Seminar in der Regel aktive Mitarbeit in den
Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen
oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten
Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung

Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [04-00-0039-se Fachdidaktisches Seminar: Algebra in der Schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z. B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht

werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen. Grading Final Module Examination: Module Examination (Technical Examination, Special Form, Weight: 100%, Standard) Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed) **Usability of the Module** Literature Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Malle, G. (1993). Didaktische Probleme der elementaren Algebra. Vieweg, Weigand, H.G, Schüler-Meyer, A. und Pinkernell, G. (2022): Didaktik der Algebra. Springer Gängige Schulbücher **Comment** 10

Mo	Module name										
	Didactics of Analysis										
Module no. 04-30- 0531/de		Credit	Points 3 CP	Workload 90 h	Self	f-study Durat			Frequency Every 2. semester		
Language of Instruction German					Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger						
1	Courses of the Module										
	Course no. Course name			e name	Workload (CP)		(CP)	Form of Teaching		Contact Hours per Week	
	04-00-0)159-se		for subject-specifics: Analysis in school				ar	2		
2	Study	Conten	t								
	Funktionspropädeutik, Funktionsuntersuchungen, Lokale Änderungsrate und Grenzwertbegriff, Riemannscher Integralbegriff, Anwendungen der Infinitisemalrechnung in der Schule, Fehlvorstellungen von Schüler*innen; Oberstufencurriculum,										

Unterrichtsgestaltung, Technologieeinsatz

3 Learning Outcomes

Die Studierenden...

...erlangen fachliche Sicherheit in besonders schulrelevanten Aspekten der Analysis und können verschiedene Zugänge und Schwerpunktsetzungen gegeneinander abwägen. ...beherrschen Darstellungen und Konzepte, um Themengebiete der Analysis in der Schule zu veranschaulichen - auch mit Technologieeinsatz. ...praktizieren in den Übungen zahlreiche Beispiele für intelligentes Üben, Diagnose und Förderung.

4 Requirements for Participation

Grundlagen des Lehrens und Lernens von Mathematik (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Duration 15 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistung: Sonderform (Im Seminar in der Regel aktive Mitarbeit in den
Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen
oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten
Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzungzur Fachprüfung

Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0160-se fachdidaktisches seminar: stochastik in der schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z. B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8	Usability of the Module Mathematik: Lehramt
9	Literature Greefrath, G., Oldenburg, R., Siller, H. S., Ulm, V., Weigand, H. G.: Didaktik der Analysis. Wiesbaden: Springer-Verlag (2016). Tietze, UP., Klika,M., Wolpers, HH.: Mathematikunterricht in der SII, Bd. 1, Fachdidaktische Grundfragen, Didaktik der Analysis. Vieweg 2000, Büchter, A., Henn, HW.: Elementare Analysis: Von der Anschauung zur Theorie. Spektrum 2010. Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Gängige Schulbücher
10	Comment

Mod	dule nar	me									
	Dida	ctics of	Stocha	astics							
Mod no.	dule	Credit	Points	Workload		Self	elf-study Duratio		on Freque		ncy
	1-30- 32/de 3 CP		90 h		60 h	1 Seme	ster	Irregula	ar		
	Language of Instruction German						on respons . Dr. phil. na				
1	Course	s of the	e Modul	le							
	Course no		Course	e name			Workload (CP)		Form of Teaching		Contact Hours per Week
	04-00-0	160-se		for subject-sp s: Stochastics			0	Seminar		2	
2	statistic Wahrsc	sche Ar cal litera cheinlicl	nalysen () acy; Dat nkeitsm	der Grundbeg enanalyse un odelle und St nwendungen,	nd Sin anda	nulat rdver	ionen mit di teilungen, Z	gitalen V ufallsgrö	Werkze ößen u	eugen, and ihre	Momente,
3	Die Stu habe Stochas besc	Learning Outcomes Die Studierenden Learning Outcomes Die Studierend									

Ideen, typische Präkonzepte und Verstehenshürden,

- ... kennen wesentliche Elemente von Lernumgebungen für den Mathematikunterricht in den genannten Themenfeldern und nutzen diese zur zielgerichteten Konstruktion von Lerngelegenheiten in heterogenen Gruppen
- ...bewerten Bildungsstandards, Lehrpläne und Unterrichtsmedien (z.B. Schulbücher, Software) und nutzen sie reflektiert für die Unterrichtsgestaltung

4 Requirements for Participation

Grundlagen des Lehrens und Lernens von Mathematik, Einführung in die Stochastik (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Duration 15 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistung: Sonderform (Im Seminar in der Regel aktive Mitarbeit in den
Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen
oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten
Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung

Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0160-se Fachdidaktisches Seminar: Stochastik in der Schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z. B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

R. Biehler, J. Engel: Stochastik: Leitidee Daten und Zufall. In R. Bruder, L. HefendehlHebeker, B. Schmidt-Thieme, G.-G. Weigand (Hrsg.): Handbuch der Mathematikdidaktik,

Springer Sprektrum 2015, S. 221 -251.

U.-P. Tietze, M. Klika, H. Wolpers: Mathematikunterricht in der Sekundarstufe II. Band 3: Didaktik der Stochastik. Vieweg 2002.

K. Krüger, H.D. Sill und C. Sikora: Didaktik der Stochastik in der Sek I. Springer 2015

10 Comment

Module Description

Module name

Didactics of Geometry

Module no.	Credit Points	Workload	Self-study	Duration	Frequency
04-30- 0533/de	3 CP	90 h	60 h	1 Semester	Every 2. semester

Language of Instruction

Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger

German

1 Courses of the Module

Course no.	Course name	Workload (CP)	Form of Teaching	Contact Hours per Week
04-10-0533-se	Didactics of Geometry	0	Seminar	2

2 Study Content

Leitideen Raum und Form, Messen, Geometrie als Tätigkeitsfeld für zeichnerisches Experimentieren und Gestalten, für analysierendes und begründendes Vorgehen in der Mathematik, für innermathematisches und anwendungsbezogenes Problemlösen und Aspekte geometrischen Denkens: Raumvorstellung und räumliches Strukturieren, Begriffsbildung, Verwendung von Darstellungen; Sprachliche Hürden in Mathematik, Vergleich von Aufgaben und Unterrichtsbausteinen in Bezug auf sprachliche Anforderungen

3 Learning Outcomes

Die Studierenden sind in der Lage...

- ... geometrische Figuren plastisch sowie durch Zeichnungen und Konstruktionen darzustellen
- ... geometrische Problemstellungen zu bearbeiten und verwendete Strategien zu reflektieren
- ... Produkte von Lernenden in Bezug auf Schwierigkeiten und Kompetenzen zu

analysieren und fachliche Unterstützungsangebote zu erarbeiten

- ... Aufgaben- und Fachtexte in Bezug auf sprachliche Anforderungen zu analysieren
- \dots binnendifferenzierende Unterrichtsbausteine zu geometrischen Themen der SI und SII zu gestalten und zu präsentieren

4 Requirements for Participation

Grundlagen des Lehrens und Lernens von Mathematik (Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Study Examination, Special Form, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Duration 15 min, Standard)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistung: Sonderform (Im Seminar in der Regel aktive Mitarbeit in denSeminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B.
Hausübungen oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung

Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-10-0533-se Fachdidaktisches Seminar: Geometrie in der Schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z. B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)
- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

Hattermann/Kadunz/Rezat/Sträßer: Leitidee Raum und Form. In Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer.

Praxis der Mathematik in der Schule (Heft 45): Ausgesprochen Mathe – Sprachen fördern ml 196: Problemlösen lernen in der Geometrie, Seelze Friedrich (2016)
Leisen, Josef (2010): Handbuch Sprachförderung im Fach. Varus Verlag
Wessel, L.(2015). Fach- und sprachintegrierte Förderung durch Darstellungsvernetzung und Scaffolding. Dortmunder Beiträge zur Entwicklung und Erforschung des Mathematikunterrichts Band 19 (Hrsg. Hußmann; Nührenbörger; Prediger; Selter).
SpringerSpektrum

Comment

Module name											
	Fach	didakti	sches S	ieminar: Medien	in d	ler Schule					
Module no. 04-30- 0534/de		Credit Points 3 CP		Workload 90 h	Self-study 60 h		Duration 1 Semester		Frequency Every 2. semester		
						Person responsible for the Module Prof. Dr. phil. nat. Katja Krüger					
1	Course	es of the	e Modu	le							
	Course no.		Cours	irse name		Workload (CP)		Teaching Ho		Contact Hours per Week	
	04-00-0	0249-se	didactio	r for subject-specific s: New media in natical lessons		0		Seminar 2		2	
2	Study Content Technische Möglichkeiten, didaktische Konzepte und Anwendungsbeispiele zu Tabellenkalkulationsprogrammen, dynamischer Geometriesoftware, Computer- AlgebraSystemen, Programmierung und didaktischer Hardware										
3	Learning Outcomes Die Studierendenerlangen Grundkenntnisse in den gängigsten Mathematikprogrammkategorien, im Umgang mit Taschenrechnern, Tablets, interaktiven Whiteboards und im Programmierenkönnen Medienanwendungen mit unterschiedlichen didaktischen Konzepten begründen und entwickeln										
4	Requirements for Participation Grundlagen des Lehrens und Lernens von Mathematik, Mediendidaktik (aus dem Vernetzungsbereich)										

(Teilnahme ohne Nachweis möglich)

5 Form of Examination

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Duration 15 min, Standard)
- Module Examination (Study Examination, Special Form, Passed / Not Passed)

Fachprüfung: Sonderform (Mündliche Prüfung mit Portfolioanteilen)
Studienleistung: Sonderform (Im Seminar in der Regel aktive Mitarbeit in den
Seminarsitzungen und erfolgreiche Bearbeitung von Lernaufträgen wie z.B. Hausübungen
oder ein Semesterprodukt. Die Kriterien diesbezüglich werden während des ersten
Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)

6 Requirements on the Award of Credit Points

Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung.

Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0249-se fachdidaktisches seminar: medien in der schule].

Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z. B. von Erfahrungen mit Unterrichtsmethoden und - materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen.

7 Grading

Final Module Examination:

- Module Examination (Technical Examination, Special Form, Weight: 100%, Standard)
- Module Examination (Study Examination, Special Form, Weight: 0%, Passed / Not Passed)

8 Usability of the Module

Mathematik: Lehramt

9 Literature

Relevante Beiträge aus Bruder et al (2015). Handbuch der Mathematikdidaktik. Springer. Barzel, B., Hußmann, S., Leuders, T. (2005): Computer, Internet Co. im MathematikUnterricht. Cornelsen Verlag Scriptor.

Artikel aus "mathematik lehren" und gängige Schulbücher

10 Comment

Module name										
Fachdidaktisches Projekt: Problemlösen										
Module no. 04-30- 0613		Credit Points 3 CP of Instruction			Self	f- study 30 h	Duration 1 Semester ible for the Mo		Frequency Every 2. semester	
Ger	man				Pro	Prof. Dr. phil. nat. Katja Krüger				
1			e Module Course name		Workload (CP)		Form of Teaching		Contact Hours per Week	
	04-00-0	043-pj	Problem	n Solving		0		Project		4
2	Study Content - Begriff und verschiedene Vorstellungen in unterschiedlichen Disziplinen zum Problemlösen lernen - Überblick über einschlägige Forschungsergebnisse mit Unterrichtsbezug - Lösen von Problemaufgaben und Reflexion von Heuristiken - Anforderungen an unterrichtsgeeignete Problemlöseaufgaben und eigene Konstruktion sowie Reflexion entsprechender Aufgaben									
3	Learning Outcomes - Entwicklung von Handlungskompetenz zur Planung von Mathematikunterricht, in dem mathematische Problemlösungskompetenz erworben werden kann - Erarbeitung und eigene Erprobung eines Konzeptes zum Problemlösen lernen, z.B. eines Knobelwettbewerbs, einer Heurismenschulung o.ä. - Gewinnen und Reflektieren eigener Problemlöseerfahrung und von Handlungswissen über Heurismen									
4	Requirements for Participation Grundlagen des Lehrens und Lernens von Mathematik, Praxissemester (Teilnahme ohne Nachweis möglich)									
5	Form of Examination Final Module Examination: [list] Module Examination (Technical Examination, Homework Assignment, Standard) [/list] Fachprüfung: Hausarbeit Studienleistung: Sonderform (In der Regel aktive Mitarbeit in den Seminarsitzungen, erfolgreiche Bearbeitung von Lernaufträgen sowie eine unterrichtspraktische Erprobung mit Schüler*innen und kontinuierliche Reflexionen in einem E-Portfolio. Die Kriterien diesbezüglich werden während des ersten Veranstaltungstermins durch die Prüferin/den Prüfer bekannt gegeben.)									

Requirements on the Award of Credit Points Bestehen der Fachprüfung; Bestehen der Studienleistung als Zulassungsvoraussetzung zur Fachprüfung Erfolgreiche Teilnahme zu 75%* an der Lehrveranstaltung [/04-00-0043-pj fachdidaktisches projekt: problemlösen lernen]. Die Anwesenheitspflicht ist für folgenden Kompetenzerwerb erforderlich: Fortwährende Diskussionen und Reflexionen z. B. von Erfahrungen mit Unterrichtsmethoden und -materialien sowie didaktischen Konzepten. Die Ziele der Lehrveranstaltung können vor allem durch die Interaktion mit den anderen Studierenden und den Lehrenden erreicht werden. Die eigene Anwesenheit sowie die Anwesenheit einer Mindestzahl von sich aktiv beteiligenden Teilnehmenden sind Voraussetzung für einen Kompetenzerwerb der Einzelnen. 7 Grading Final Module Examination: Module Examination (Study Examination, Portfolio, Weight: 0%, Passed / Not Passed) Module Examination (Technical Examination, Homework Assignment, Weight: 100%, Standard) **Usability of the Module** 8 Mathematik: Lehramt 9 Literature Comment 10