Modulhandbuch M.Sc. Mechanics

Studienbereich Mechanik FB 13 Stand: 10.12.2024



TECHNISCHE UNIVERSITÄT DARMSTADT

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1 Mandatory Area

Mo Nor	dule name ilinear Finite I	Element Methods (F	EM II)							
Mo 13-1	dule nr. E1-M020	Credit points 6 CP	Workload 180 h	Self-stu	d y 120 h	Module durat 1 Term	tion	Module cy Every 2. Se	rcle emester	
Lan Eng	i guage lish			Module Prof. Dr	owner Ing. Rali	f Müller, Prof. D	rIng	. Dominik So	chillinger	
1	Courses of t	his module								
	Course nr.	Course name		Workload (CP)			Теас	ching form	HPW	
	13-E1-0005-vlFinite Element Methods II0Lecture2									
	13-E1-0006-	ue Finite Element	Methods II - Exer	cise	0		Prac	tice	2	
2	Teaching co	'eaching content								
3	Learning objectives									
4	Prerequisite for participation									
5	Form of exa Module exar • Module • Module	mination n: e exam (Technical ex e exam (Study achie	amination, Oral e vement, Domestic	examinati work, p/	on, Durat np RS)	ion: 30 Min., D	efault	RS)		
6	Prerequisite Passing the f	e for the award of c	redit points ation							
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 100 %) Module exam (Study achievement, Domestic work, Weighting: 0 %) 									
8	Usability of	Usability of the module								
9	References	eferences								
10	Comment	Comment								

Mo Cor	dule name itinuum Mech	anics II (Material Th	neory)							
Mo	dule nr.	Credit points	Workload	Self-stu	120 h	Module durat	tion	Module cy	rcle	
I3-	E2-IVI003	0 CP	180 h	Module owner						
Eng	lish			Prof. DrIng. Ralf Müller, Prof. DrIng. Dominik Schillinger						
1	Courses of t	his module								
	Course nr.	Course name			Workloa	ad (CP)	Теас	ching form	HPW	
	13-E2-0006-vl Continuum Mechanics II (Material Theo- v) Lecture 3						3			
	13-E2-0007-ueContinuum Mechanics II (Material Theo- ry) - Exercise0Practice1									
2	Teaching content Linear and nonlinear elasticity theory, thermoelasticity, stability, wave propagation, acceleration waves - acoustic tensor, introduction in viscoelasticity and plasticity (for small and large deformations), micropolar elasticity, numerical aspects									
3	Learning objectives The students have the capability of analysing specific tasks, generating solutions and applying mathematical- scientific methods to engineering problems.									
4	Prerequisite Knowledge of necessary.	e for participation of 'Tensorrechnung f	ür Ingenieure' (13	8-E2-M00	4) and 'K	ontinuumsmech	nanik	I' (13-E2-M	002) is	
5	Form of exa Module exar • Module	mination n: e exam (Technical ex	αamination, Oral ε	examinati	on, Durat	ion: 30 Min., D	efault	RS)		
6	Prerequisite Passing the r	e for the award of c nodule examination	redit points (s)							
7	Grading Module exar • Module	n: e exam (Technical ex	xamination, Oral e	examinati	on, Weigł	nting: 1)				
8	Usability of	the module								
9	References Literature w	ill be announced at t	he beginning of th	ne course						
10	Comment									

Mo Sen	dule name ninar Continu	um Mechanics							
Mo 13-	dule nr. E2-M009	Credit points 4 CP	Workload 120 h	Self-stu	1 dy 90 h	Module durat 1 Term	tion	Module cy Every Sem	v cle ester
Lan Eng	i guage Ilish			Module Prof. Dr	e owner Ing. Rali	f Müller, Prof. D	rIng	. Dominik So	chillinger
1	Courses of t	this module							
	Course nr.	Course name			Workloa	ad (CP)	Теас	ching form	HPW
	13-E2-0003-seSeminare Continuum Mechanics0Seminare2								
2	Teaching content								
3	Learning objectives								
4	Prerequisite	e for participation							
5	Form of exa Module exar • Module	mination n: e exam (Technical ez	amination, Specia	al form, I	Ouration: 2	20 Min., Defaul	t RS)		
6	Prerequisite Passing the f	e for the award of c inal module examina	redit points ation						
7	GradingModule exam:Module exam (Technical examination, Special form, Weighting: 1)								
8	Usability of	the module							
9	References								
10	Comment								

Mo Sen	Module name Seminar Computational Mechanics									
Mo 13-1	dule nr. E1-M021	Credit points 4 CP	Workload 120 h	Self-stu	dy 90 h	Module durat	tion Module cycle Every Semester		v cle ester	
Lan Eng	iguage lish			Module owner Prof. DrIng. Ralf Müller, Prof. DrIng. Dominik Schillinger						
1	Courses of t	his module								
	Course nr.	Course name			Workloa	ad (CP)	Теас	ching form	HPW	
	13-E1-0021-	se Seminar Comp	utational Mechan	ics	0		Sem	inar	2	
2	Teaching content									
3	Learning objectives									
4	Prerequisite	e for participation								
5	Form of exa Module exar • Module	mination n: e exam (Technical ex	amination, Specia	al form, D	ouration: 2	20 Min., Defaul	t RS)			
6	Prerequisite Passing the f	e for the award of c	redit points ation							
7	GradingModule exam:Module exam (Technical examination, Special form, Weighting: 1)									
8	Usability of	the module								
9	References									
10	Comment									

Mo Res	dule name earch Semina	r Applied Dynamics							
Mo 16-2	dule nr. 25-611b	Credit points 3 CP	Workload 90 h	Self-stu	dy 60 h	Module dura 1 Term	tion	Module cy Every Sem	v cle ester
Lan Ger	n guage man			Module Prof. Dr	owner Richard	Markert			
1	Courses of t	this module							
	Course nr.	Course name			Workloa	ad (CP)	Теас	ching form	HPW
	16-25-5110-fsResearch Seminar Applied Dynamics0Research semi- nar2								
2	Teaching co	ontent							
3	Learning objectives								
4	Prerequisite	e for participation							
5	Form of exa Module exar • Module	mination n: e exam (Study achie	vement, Study ach	nievemen	t, Default	RS)			
6	Prerequisite Passing the f	e for the award of c	redit points ation						
7	Grading Module exar • Module	n: e exam (Study achie	vement, Study ach	nievemen	t, Weighti	ing: 100 %)			
8	Usability of	the module							
9	References								
10	Comment								

Mo Sen	dule name ninar Fluid M	echanics, Contin	uum Mec	hanics and C	Geophysic	al Mecha	nics				
Mo 16-0	dule nr. 64-617b	Credit points 3	CP Wo	rkload 90 h	Self-stu	Self-study Mod 60 h 1 Te		tion	Module cycle Every Semester		
Lan Ger	i guage man				Module owner Apl. Prof. DrIng. Yongqi Wang, Prof. DrIng. Martin Oberlack						
1	Courses of t	this module									
	Course nr.	Course na	me			Worklo	ad (CP)	Теас	ching form	HPW	
	16-64-5170-seSeminar in Fluid Mechanics, Continuum0Seminar2Mechanics and Geophysical MechanicsAmerican SeminarAmerican SeminarAmerican SeminarAmerican Seminar										
2	Teaching co Presentation Mechanics.	ontent of present scient	ific works	and/or work	ting on a s	cientific to	ext in Fluid Mecl	nanics	and/or Cont	inuum	
3	 Learning objectives On successful completion of this module, students should be able to: 1. Screen and analyse the relevant scientific literature in databases, libraries and third-party sources. 2. Structure a given task and organise a realistic time schedule. 3. Formulate the results in written and oral form in an accepted scientific manner. 										
4	Prerequisite Basic knowle	e for participation for participation for participation for the second s	on atics and :	mechanics							
5	Form of exa Module exar • Modul Written elab	m ination n: e exam (Study a oration and oral	chieveme exam 30	ent, Study ac min.	hievemen	t, Default	RS)				
6	Prerequisite Passing the e	e for the award	of credit	points							
7	Grading Module exar • Module	n: e exam (Study a	chieveme	ent, Study ac	hievemen	t, Weight	ing: 100 %)				
8	Usability of Master Mech	the module 1anik									
9	References Reference su	iggestions will be	e provide	 d.							
10	Comment										

2 Elective Area A: Advanced Modules in Mechanics

Mo Stru	dule name Ictural Durabi	lity								
Mo 13-1	dule nr. 12-M001	Credit p	ooints 6 CP	Workload 180 h	Self-stu	d y 120 h	Module durat	tion	Module cy Every 2. Se	v cle emester
Lan Ger	i guage man				Module Prof. Dr	owner Ing. Mic	hael Vormwald			
1	Courses of t	his modu	ıle							
	Course nr.	Cou	rse name			Workloa	ad (CP)	Теа	ching form	HPW
	13-I2-0001-v	vl Stru	ctural Dura	ability		0		Lect	ure	2
	13-I2-0002-ı	ie Stru	ctural Dura	ability - Exercise		0		Prac	ctice	2
2	Materials mechanics basics: deformation and failure behaviour under constant and variable amplitude loading Overview on life assessment approaches Load date analysis and cycle counting methods Local strain approach - computer aided fatigue analysis, nominal, structural, and notch stress approach Standards and codes for the proof of structural durability Fatigue crack growth									
3	Learning objectives After finishing this lecture students are able to: Determine fatigue loads and apply cycle counting methods, evaluate statistically the results of experimental investigations, perform a proof of structural durability according to actual technical standards, rank all approaches for proof of structural durability with respect to their required effort and their expected accuracy as well as apply such approaches, improve the the structural durability by appropriate methods									
4	Prerequisite	e for parti	icipation							
5	Form of exa Module exar • Module	mination n: e exam (T	echnical e	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	RS)	
6	Prerequisite Passing the r	e for the a nodule ex	award of c amination	redit points (s)						
7	Grading Module exar • Module	n: e exam (T	echnical e	xamination, Oral 6	examinati	on, Weigł	nting: 1)			
8	Usability of	the modu	ule							
9	References Lecture note Radaj, D., Vo 2007 Radaj, D., Vo Haibach, E.,	s, script. rmwald, M prmwald, I Betriebsfe	M.: Ermüdu M.: Advano estigkeit, S	ıngsfestigkeit - Gru ed Methods of Fat pringer, 2002, ISE	indlagen f igue Asse N 3-540-	für Ingeni ssment, S 43142-x	eure, Springer, I pringer, ISBN 9	SBN 9 78-3-0	978-3-540-71 642-30739-3	1458-3, 3, 2013
10	Comment									

Mo Fra	dule name cture Mechan	ics									
Мо	dule nr.	Cr	edit points	Workload	Self-stu	ıdy	Module durat	tion	Module cy	vcle	
13-	I2-M002		6 CP	180 h	n 120 h 1 Term Every 2. Sem						
Lar Ger	iguage man				Module owner Prof. DrIng. Michael Vormwald						
1	Courses of	this	module								
	Course nr.		Course name			Workload (CP)		Teaching form		HPW	
	13-I2-0007-	vl	Fracture Mecha	anics		0		Lect	ure	3	
	13-I2-0008-ueFracture Mechanic - Exercise0Practice1							1			
2	Teaching contentBasics of the Theory of Elasticity, near crack tip solutions, stress intensity factorsNumerical methods based on the Finite Element technology and on weight functionsLaboratory techniques for determining critical valuesEnergy release rates, J-integral, strip-yield and cohesive-zone models, crack tip opening displacementProof of strenght based on Failure-Assessment and Crack-Driving-Force diagramsFatigue crack growth including load sequence and short crack effects										
3	Learning of After finishi Decide whice and effort, calculate str evaluate the assess the re calculate fat	ress i e stre sult	nis lecture studer umerical method intensity factors. ength of structure s of experimenta e crack growth liv	nts are able to: l provides stress ir J-integrals, and c es with defects, l investigations, ves.	ntensity f	actors wit	ch an optimum splacements,	with	respect to ac	curacy	
4	Prerequisit	e foi	r participation								
5	Form of exa Module exa • Modul	a mir m: le ex	nation am (Technical e:	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	t RS)		
6	Prerequisite Passing the	e foi mod	r the award of c ule examination	redit points (s)							
7	Grading Module exame • Module	m: le ex	am (Technical e:	xamination, Oral e	examinati	on, Weigl	nting: 1)				
8	Usability of	the	module								
9	References										
10	Comment										

Mo Cor	dule name nputational P	lasti	city										
Mo 13-	dule nr. E1-M019	Cr	edit points 6 CP	Workload 180 h	Self-stu	study Module dur 120 h 1 Term		ion	Module cy Every 2. Se	r cle emester			
Lar Eng	1guage glish	1		I	Module Prof. Dr	Module owner Prof. DrIng. Ralf Müller, Prof. DrIng. Dominik Schillinger							
1	Courses of	this	module					0					
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW			
	13-E1-0019-	-vu	Computational	Plasticity		0		Lect prac	ure and tice	4			
2	 Freaching content Part I: One-dimensional plasticity: formulation and numerical implementation 1. Derivation of one-dimensional constitutive equations, building on the phenomenological interpretation of plasticity 2. Strong and weak forms of the initial boundary value problem (IBVP), its discretization and linearization 3. Integration algorithms (return map algorithms) for one-dimensional constitutive equations Part II: Three-dimensional classical rate-independent plasticity 1. Review of classical governing equations within continuum mechanics and thermodynamics 2. Theory of yield surfaces and classical small-strain plasticity models 3. Maximum plastic dissipation principle and its interpretation as a constrained convex optimization problem 4. Derivation of constitutive equations from convex optimization principles Part III: Integration algorithms for plasticity 1. Incremental form of constitutive equations and geometric interpretation as closest point projection 2. Radial return map algorithm for J2 plasticity 3. General return map algorithms (closest point projection algorithms, cutting plain algorithms) 												
3	Learning of Students dev their mather multidimens models, line the finite ele	velop matio siona ariza emer	tives o a rigorous under cal foundations f l problems for in- ation of nonlinea nt method.	erstanding of integ rom a convex opti elastic solids focus r global governing	ration alg mization j ing on ret equation:	orithms fo perspectiv urn map a s, and dise	or elastoplastic c re. They are able lgorithms for ra cretization and s	onstit e to so te-ind solutio	utive probler lve and imp ependent pla on in the con	ms and lement asticity ntext of			
4	Prerequisite Recommend	e for led: '	participation "Finite Element 1	Methods I" (13-E1	-M001) s	hould be	taken in paralle	l.					
5	 Form of examination Module exam: Module exam (Technical examination, Oral examination, Duration: 15 Min., Default RS) Module exam (Study achievement, Domestic work, Default RS) Technical Examination (oral examination): Presentation (25% Weight) and oral examination (15 min., 25% Weight) Study Examination (homework assignment): Submission of 5 homework assignments (assessment: 10% Weight each) distributed over the lecture period. 								., 25% Weight				
6	Prerequisit Passing the	e for mod	the award of c ule examination	redit points (s)									
7	Grading												

	 Module exam: Module exam (Technical examination, Oral examination, Weighting: 50 %) Module exam (Study achievement, Domestic work, Weighting: 50 %)
8	Usability of the module
9	References Simo, J.C. and Hughes, T.J., 2006. Computational Inelasticity. Springer Science & Business Media. de Souza Neto, E.A., Peric, D. and Owen, D.R., 2011. Computational Methods for Plasticity: Theory and Applications. John Wiley & Sons.
10	Comment

Mo Me	dule name chanics of Gla	cier	s and Ice Sheets							
Mo	dule nr.	Cr	edit points	Workload	Self-stu	dy	Module durat	tion	Module cy	vcle
13-	E2-M008		6 CP	180 h		120 h	1 Term		Every 2. Se	emester
Lan Eng	guage lish				Prof. Dr	owner -Ing. Ralf	Müller, Prof. D	rIng	. Dominik So	chillinger
1	Courses of t	his	module		I					
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW
	13-E2-0014-	vl	Mechanics of G	laciers and Ice Sh	eets	0			ure	3
	13-E2-0015-	ue	Mechanics of Exercises	Glaciers and Ice	Sheets -	0		Prac	tice	1
2	 Teaching content Ice sheet, ice stream-glacier systems and their dynamics Structure of ice and constitutive relations Balance equations of ice sheets and glaciers, boundary conditions and approximations Processes in ice sheets: firn densification, sliding, calving and ice sheet hydrology recent research topics in ice sheet dynamics and stability 									
3	 3 Learning objectives After successful completion of the module, students will have acquired an understanding of ice sheet and glacier dynamics and its processes, as well as having experience in applying the methods of continuum mechanics in glaciology. 									
4	Prerequisite Basic knowle	e for edge	participation in mathematics	, physics and mec	hanics.					
5	Form of exa Module exar • Module	min n: e exa	a tion am (Technical ex	amination, Oral e	examinati	on, Durat	ion: 20 Min., D	efault	RS)	
6	Prerequisite Passing the r	e for nod	the award of c ule examination	redit points						
7	Grading Module exar • Modul	n: e ex	am (Technical ex	amination, Oral e	examinati	on, Weigh	nting: 100 %)			
8	Usability of	the	module							
9	 References Cuffey&Patterson, Physics of Glaciers, 2010 Greve & Blatter 'Dynamics of Glaciers and Ice Sheets' Monograph, Series Advances in Geophysical and Environmental Mechanics" (AGEM), Springer, 2007 									
10	0 Comment									

Mo	dule name	beci	al Relativity							
Mo 13-	dule nr. E2-M018	Cr	edit points	Workload 90 h	Self-stu	1 dy 60 h	Module durat	ion	Module cy Every 2. Se	/ cle
Lan	iguage		0.01	70 II	Module	owner	1 Icim		livery 2. oc	
Ger	rman Gaunaa af	41. : -			Prof. Dr	Ing. Rali	f Müller, Prof. D	rIng	. Dominik So	chillinger
1	Courses of Course nr.	unis	Course name			Workloa	ad (CP)	Tea	ching form	
	13-E2-0018	-vl	Einführung in theorie	die Spezielle Rela	ativitäts-	0		Lect	ure	HPW 2
2	 Teaching content Vectoranalysis in threedimensional Euclidean space Newtonian mechanics, Maxwell equations in electrodynamics Galileian relativity principle Constancy of light velocity, Lorenz transformation, light cone Minkowski fourdimensional spacetime Relativistic particle mechanics, relativistic hydromechanics, relativistic formulation of Maxwell equations Learning objectives 									
3	Learning objectives After successful completion of the module, - students will have basic knowledge of space-time-structures and invariance properties of physical theories - they will have mastered the kinematics of relativistic mechanics and its consequences, e.g., length contraction and time dilatation - they will have learned the fundamental equations of relativistic dynamics as well as relativistic formulations of momentum, energy and mass									
4	Prerequisit Recomment	e for led:	participation Basics in tensor	calculus and linea	r algebra					
5	Form of exa Module exa • Modul	a min m: le ex	nation am (Technical e	xamination, Oral 6	examinati	on, Durat	ion: 20 Min., D	efault	t RS)	
6	Prerequisit Passing the	e for mod	the award of c ule examination	redit points (s)						
7	Grading Module exa • Modu	m: le ex	am (Technical e	xamination, Oral 6	examinati	on, Weigł	nting: 100 %)			
8	Usability of	the	module							
9	References U.E. Schröder: Spezielle Relativitätstheorie, Verlag Harri Deutsch, 2007 Ray d'Inverno: Einführung in die Relativitätstheorie, Wiley-VCH Verlag, 2009 David Tong: Lectures in Dynamics and Relativity, University of Cambridge, 2013,verfügbar unter htt- ps://www.damtp.cam.ac.uk/user/tong/relativity/seven.pdf Bernard F. Schutz: A first course in general relativity, Cambridge Univerity Press, 2004 E. Taylor and J. Wheeler, Spacetime Physics, Freeman, San Francisco, 1966									
10	Comment	Comment								

Mo Ana	dule name alytical Mecha	nics								
Mo 13-	dule nr. E2-M016	Cr	edit points 6 CP	Workload 180 h	Self-stu	dy 120 h	Module durat	tion	Module cy Every 2. Se	r cle emester
Lan Eng	iguage lish	1			Module Prof. Dr	owner -Ing. Rali	f Müller, Prof. D	rIng	. Dominik So	chillinger
1	Courses of t	his	module							
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW
	13-E2-0016-	vl	Analytical Mec	hanics		0		Lect	ure	3
	13-E2-0016-	ue	Analytical Mec	hanics - Exercise		0		Prac	tice	1
3	onstraints, generalized coordinates-virtual displacements, principles of d'Alembert and Jourdain-Lagrange equations of second and first kind-generalized potentials, Lagrange formalism with friction-cyclic coordinates, canonical momentum-elements of variational calculus, Hamilton's principle-Legendre transformations, Hamilton's equations-Poisson brackets, canonical transformations-Hamilton-Jacobi-Theory-transition to wave mechanicsLearning objectivesAfter successful completion of the module the student is able to-classify the several types of constraints and describe mechanical systems by means ofconstraint forces-derive d'Alembert's principle by means of the concept of virtual displacements-apply Lagrange's equations for solving of mechanical problems-derive Hamilton's equations by means of the Legendre transformations									
	-apply Lagran mass system -derive the H -understand	s an Iami the	d rigid bodies ilton-Jacobi equa Hamilton-Jacobi	ition by means of theory as the bas	canonical is for the	transform construct	nations ion of a theory of	of wa	vemechanics	, рош-
4	Prerequisite Recommend	e fo r ed: 1	participation Knowledge in An	alysis, Technische	Mechanik	I, II, III (13-E0-M001, 13	-E0-N	1002, 13-E0-	M003)
5	Recommended: Knowledge in Analysis, Technische Mechanik I, II, III (13-E0-M001, 13-E0-M002, 13-E0-M003) Form of examination Module exam: • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) Subject Examination: Oral Examination (30 min.) / Written Examination (90 min.) Type of examination: The examination is oral. If there is a recognizable permanent increase in the number of participants, the examination form will be changed to a written exam									
6	Prerequisite Passing the 1	e fo r nod	the award of c ule examination	redit points (s)						
7	Grading Module exar • Modul	n: e ex	am (Technical ex	amination, Oral/	written ez	kaminatio	n, Weighting: 1	00 %)	
8	Usability of	the	module							
9	References									

	F.Kuypers: Klassische Mechanik, Wiley-VCH Verlag, 2016 W.Nolting: Grundkurs Theoretische Physik 2: Analytische Mechanik, Springer Verlag, 2014 W.Greiner: Klassische Mechanik II, Verlag Harri Deutsch, 2008 H.Goldstein: Classical Mechanics, Pearson Verlag, 2013 Further literature will be announced at the beginning of the course
10	Comment

Mo Fini	dule name ite Elements I	II: S	tabilized Method	ls for Computatio	nal Fluid	Dynamics	5					
Mo	dule nr.	Cr	edit points	Workload	Self-stu	dy	Module durat	ion	Module cy	cle		
13	EI-MOI8		6 CP	180 h	Madula	Module owner						
Eng	l guage lish				Prof. Dr	Prof. DrIng. Ralf Müller, Prof. DrIng. Dominik Schillinger						
1	Courses of t	his	module		I			0				
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW		
	13-E1-0018-	vu	Finite Elements	s III		0		Lect prac	ture and	4		
2	 2 Teaching content Part I: Fundamentals, mathematical background and problem statements Prototypical fluid mechanics equations: the advection(-diffusion), Burgers, Stokes and Navier-Stokes equations Relevant components of functional analysis theory Analysis of the model equations with emphasis on the challenges of finite element formulations Part II: Solution strategies Stabilized methods; Galerkin least-squares (GLS), artificial diffusion, streamline-upwind Petrov-Galerkin (SUPG) Suitable interpolation pairs in mixed methods (e.g. Taylor-Hood) Discontinuous Galerkin methods Part III: Multiscale modeling A short introduction to the physics of turbulence Classical turbulence models: Reynolds-averaged Navier-Stokes (RANS) and large eddy simulation (LES) The variational multiscale method 											
3	Learning of Understandi finite element Knowledge of polation pair some open r element met	oject ng o nt th of sta rs. B resea hod	tives of potential benef neory and challes abilized method asic understandi arch questions in in this context v	its of using the fin nges that arise wh s, discontinuous G ing of turbulence this area. Unders with respect to fini	ite eleme nen the fir Galerkin f modeling standing o ite volume	nt method nite eleme ormulatio and the v of the adv e method	d for flow proble ent method is a ons and suitable variational mult rantages and dis s.	ems, a pplied velod iscale sadva	advanced asp d to flow pro city/pressure method, inc ntages of the	ects of oblems. e inter- luding e finite		
4	Prerequisite Recommend	e for ed: 1	participation Finite-Element-N	/lethoden I (13-E1	-M001)							
5	 Form of examination Module exam: Module exam (Study achievement, Domestic work, Default RS) Module exam (Technical examination, Oral examination, Duration: 15 Min., Default RS) Study Achievement (homework assignment): Submission of 7 homework assignments (assessment: 10% Weight each) distributed over the lecture period. 											
6	Prerequisite Passing the 1	e for nod	the award of c ule examination	redit points (s)								
7	Grading											

	 Module exam: Module exam (Study achievement, Domestic work, Weighting: 70 %) Module exam (Technical examination, Oral examination, Weighting: 30 %)
8	Usability of the module
9	 References J. Donea, A. Huerta: Finite Element Methods for Flow Problems (2003), Wiley. T.J.R. Hughes et al.: Multiscale and Stabilized Methods. In: Encyclopedia of Computational Mechanics (2018), Part 1 Fluids, Chapter 2. B. Cockburn: Discontinuous Galerkin Methods for Computational Fluid Dynamics. In: Encyclopedia of Compu- tational Mechanics (2018), Part 1 Fluids, Chapter 5.
10	Comment

Mo Aer	dule name odynamics II									
Mo	dule nr.	Cr	edit points	Workload	Self-stu	dy 135 h	Module durat	tion	Module cy	/ cle
Lar Eng	iguage glish		0.01	100 11	Module Prof. Dr	owner Ing. Jean	nette Hussong			
1	Courses of	this	module							
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW
	16-11-5060-vlAerodynamics II0					Lect	ure	3		
2	Teaching co Compressibl airfoil theor	onte e flo y, lift	nt ws: stream filan ting-line theory,	nent theory, shock compressible bour	waves, P ndary laye	randtl-Me ers.	eyer expansions	, gas (dynamic equ	iations,
3	 Learning objectives On successful completion of this module, students should be able to: Describe the fundamental differences of the theoretical treatment of compressible flows as compared to incompressible flows. Explain the processes responsible for the occurrence of shocks and expansion waves and their influence on the aerodynamic characteristic. Apply the procedures for compensating the compressibility effects in incompressible computed flows. Explain the effects of compressibility on the aerodynamic features of airfoils and aircraft and methods of utilizing or avoiding such effects. Describe the impact of compressibility on boundary layer flows. 									
4	Prerequisit Aerodynami	e for cs I :	participation recommended							
5	Form of exa Module exa • Modul Oral (30 min	n min n: e exa n) or	a tion am (Technical e: written exam (xamination, Oral/ 60 min)	written ex	kaminatio	n, Default RS)			
6	Prerequisit Passing the	e for exan	the award of c	redit points						
7	Grading Module exan • Modul	n: e ex	am (Technical e	xamination, Oral/ [,]	written ez	xaminatio	n, Weighting: 1	.00 %)	
8	Usability of Tropea/Gru Strömungsle Tropea/Gru	the ndm hre ndm	module ann Aerodynam und Aerodynam ann Aerodynam	ik II (Shaker Verla ik ik II (Shaker Verla	g), erhält g), availa	lich im So ble at FG	ekretariat des F office	achge	biets	
9	References Tropea/Gru	ndm	ann Aerodynam	ik II (Shaker Verla	g), availa	ble at FG	office			
10	Comment									

Mo Apr	dule name blied Structura	al O	ptimization							
Mo 16-	dule nr. 19-5040	Cr	edit points 4 CP	Workload 120 h	Self-stu	dy 75 h	Module dura 1 Term	tion	Module cy Winter terr	v cle m
Lar Ger	nguage man	1. • -			Module Prof. Dr	e owner . rer. nat.	Lothar Harzhei	m	1	
1	Courses of t	:nis	Course name			Worklo	ad (CP)	Теа	ching form	
	Gourse III.		Course name			WOINIO		ICa		HPW
	16-19-5040-	vl	Applied Structu	Iral Optimization		0		Lect	tico	2
<u>ר</u>	Teaching co	nto	Applied Structu			0		Plac		
2	Objectives of structural optimization; mathematical basics: extrema, convexity, Lagrange function and multiplica- tors, Kuhn-Tucker conditions, saddle point properties; optimization methods: gradient methods, approximation methods, response-surface methods, optimality criteria, evolutionary strategies; optimization strategies: multi- objective optimization, multi-disciplinary optimization, multi-level optimization, consideration of spreading of structural parameters, robust design; including of finite-element method in optimization process; programs and application areas: wall thickness optimization, shape optimization, topology optimization.									
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Recall the objectives of structural optimization and the associated mathematical basics. 2. Explain and differentiate the concepts of extrema, convexity, Lagrange function, and multiplicators. 3. Describe the Kuhn-Tucker conditions and saddle point properties and their relevance. 4. Repeat the basics of gradient methods, approximation methods, response-surface methods, optimality criteria, evolutionary strategies. 5. Recognize strategies for multi-objective optimization, multi-disciplinary optimization, multi-level optimization, consideration of spreading of structural parameters, and robust design. 6. Apply the finite-element method into the optimization process. 7. Name codes for structural optimization and describe important application areas for wall thickness optimization, shape optimization, and topology optimization. 									
4	Prerequisite Numerical M	e fo i Iath	r participation ematics and Nun	nerical Methods re	ecommen	ded				
5	Form of exa Module exar • Modul Oral exam 3	min n: e ex 0 m	nation am (Technical ex in	amination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	t RS)	
6	Prerequisite Passing the e	e fo r	r the award of c nination	redit points						
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 100 %) 									
8	 B Usability of the module WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master Mechatronik 									
9	Master Mechatronik References lecture notes (available in lecture); Schumacher, Optimierung mechanischer Strukturen, Springer, 2004									

10	Comment

Mo Bas	dule name ic Phenomena	ı in l	Multiphase Flow	s						
Mo 16-	dule nr. 11-3214	Cr	edit points 4 CP	Workload 120 h	Self-stu	1 dy 90 h	Module durat	tion	Module cy Every 2. Se	/ cle emester
Lan Eng	iguage ;lish	I			Module DrIng.	e owner Ilia Roisn	nan			
1	Courses of	this	module							
	Course nr.		Course name		Workload (CP)			Теа	ching form	HPW
	16-11-3214-	vl	Basic Phenome	na in Multiphase	Flows	0		Lect	ure	2
2	Teaching co Introduction and aerosols media, gran	nter; Sin ; Sin ; Int ular	nt gle particle moti eraction phenon flows; Flows wit	on; Bubble transpo nena in sprays; Su h phase change.	ort, bubbl spensions	e dynami and emu	cs; Thin liquid f lsions; Flows in	ilms; poro	Instabilities; us media; Gı	Sprays ranular
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Identify different types and basic phenomena of multiphase flows 2. Solve elementary problems related to multiphase flows 3. Evaluate and present modern scientific publications in the field of multiphase flows 									
4	Prerequisite for participation Fundamental Fluid Mechanics recommended									
5	Form of exa Module exa • Modul Oral exam 3	min n: e exa 0 mi	ation am (Technical ex n	αamination, Oral ε	examinati	on, Durat	ion: 30 Min., D	efault	t RS)	
6	Prerequisite Passing the	e for exan	the award of c nination	redit points						
7	Grading Module exan • Modul	n: e ex	am (Technical ex	αamination, Oral ε	examinati	on, Weigł	nting: 100 %)			
8	Usability of WPB Master WPB Master	the MB PST	module III (Wahlfächer III (Fächer aus	aus Natur- und In Natur- und Ingeni	genieurw eurwisse	rissenscha nschaft fü	ft) r Papiertechnik)		
9	 9 References Ashgriz (ed.) Handbook of atomization and sprays. Springer 2011 Crowe, Clayton T., (ed.) Multiphase flow handbook. Vol. 59. CRC press, 2005. Yarin, A.L., Roisman, I. V., Tropea, C, Collision Phenomena in Liquids and Solids. Cambridge University Press, 2017. 									
10	Comment									

Mo Dyr	dule name namics of Inte	rfacia	ll Flows								
Mo	dule nr.	Cre	dit points	Workload	Self-stu	dy	Module durat	ion	Module cy	v cle	
16-	11-3224		4 CP	120 h		90 h	1 Term		Every 2. Se	emester	
Lan Eng	g uage lish				Module owner DrIng. Ilia Roisman						
1	Courses of	this n	nodule								
	Course nr.		Course name			Workload (CP)			ching form	HPW	
	16-11-3224-	vl	Dynamics of In	terfacial Flows		0		Lect	ure	2	
2	Teaching co Introduction interface; We problem; Pla	onten 1; Sur etting ateau	t face Tension; S ; Dynamic conta - Rayleigh insta	Stress Boundary C act angle; Wall flow ability of an infinit	Conditions vs; Dynam e cylinde	s; Static l lics of thir r; Oscillat	iquid shapes; C liquid films; Di tions of a liquid	Capilla p coat drop;	ary waves or ting: Landau- ;Marangoni]	ı a flat -Levich Flows.	
3	 3 Learning objectives On successful completion of this module, students should be able to: Identify basic interfacial phenomena which influence various engineering problems Solve hydrodynamic problems with capillary flows in drops, films, and jets Evaluate and present modern scientific publications in the field of hydrodynamics of capillary flows 										
4	Prerequisite for participation Fundamental Fluid Mechanics recommended										
5	Form of exa Module exar • Modul Oral exam 3	i mina n: e exa 0 min	n tion m (Technical ex	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	t RS)		
6	Prerequisite Passing the e	e for (exami	the award of c ination	redit points							
7	Grading Module exan • Modul	n: e exa	m (Technical ex	xamination, Oral e	examinati	on, Weigł	nting: 100 %)				
8	Usability of WPB Master WPB Master	the r MB I PST	nodule II (Wahlfächer III (Fächer aus I	aus Natur- und In Natur- und Ingeni	genieurw eurwissei	issenscha 1schaft fü	ft) r Papiertechnik)			
9	 P References D.A. EDWARDS, H. BRENNER, D. T. WASAN, Interfacial Transport Processes and Rheology, Butterworth, 1993. S. CHANDRASEKHAR, Hydrodynamic and Hydromagnetic Stability, Clarendon Press, 1961. B. G. LEVICH, Physicochemical Hydrodynamics, 1962. A. L. YARIN, Free liquid jets and films: Hydrodynamics and Rheology, Longman Scientific&Technical, 1993. De Gennes, P. G., Brochard-Wyart, F., & Quéré, D., Capillarity and wetting phenomena: drops, bubbles, pearls, waves. Springer Science & Business Media., 2013 Comment 										
	Comment										

Mo	dule name	Mech	nanics II							
Mo 16-0	dule nr. 64-5120	Cr	edit points 6 CP	Workload 180 h	Self-stu	dy 120 h	Module durat	tion	Module cy Every 2. Se	cle emester
Lan Ger	guage man	1		I	Module Apl. Pro	e owner of. DrIng.	Yongqi Wang			
1	Courses of	this	module							
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW
	16-64-5120-	vl	Advanced Fluid	l Mechanics II		0		Lect	ure	3
	16-64-5120-	·ue	Advanced Fluid	l Mechanics II		0		Prac	tice	1
2	Teaching co Basic equation flows; Steac layer flows;	onter ons c ly an Intro	nt of incompressible ad unsteady com oduction of acous	and compressible pressible flows; P stics; Viscoelastic	fluid flow erpendicu flows	vs; Jump c ular and r	conditions on sir noving shocks;	ngular Comp	surfaces; Popressible bo	otential undary
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Describe incompressible and compressible flows in a differentiated way and explain the balance equations 2. Construct jump conditions on phase interfaces or shocks 3. Describe flows of ideal fluids by means of potential theory 4. Solve compressible flow problems involving shock waves 5. Derive simplified equations of compressible boundary layer flows 6. Develop a fundamental understanding of acoustic phenomena 7. Understand various modelings and behaviors of viscoelastic fluids 									
4	Prerequisite Recommend Knowledge	e for led a of Pa	participation re: 1) Fundament rt I of this lectur	ntals of fluid mech re is not required.	nanics, 2)	Ordinary	and partial diff	ferent	ial equation	
5	Form of exa Module exa • Modul	min m: .e exa	a tion am (Technical ex	xamination, Oral 6	examinati	on, Durat	ion: 30 Min., D	efault	RS)	
6	Prerequisit Passing the	e for exan	the award of c nination	redit points						
7	Grading Module exame • Module	m: e ex	am (Technical ez	xamination, Oral 6	examinati	on, Weigł	nting: 100 %)			
8	8 Usability of the module WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Angewandte Mechanik									
9	 References Hutter, K., and Wang, Y.: Fluid and Thermodynamics. Springer Verlag. Volume 1: Basic Fluid Mechanics (2016), Volume II: Advanced Fluid Mechanics and Thermodynamic Fundamentals (2016), Volume III: Structured and Multiphase Fluids (2018). Lecture Notes in moodle 									
10	0 Comment									

2	E
2	Э.

Mo Hig	Module name High-Accuracy Methods for Computational Fluid Dynamics									
Mo 16-0	Iodule nr.Credit pointsWorkloadSelf-s6-64-32646 CP180 h				Self-stu	idy 120 h	dy Module duration		Module cy Every 2. Se	v cle emester
Lan Eng	i guage lish				Module DrIng.	owner Florian K	ummer		-	
1	Courses of	this	module							
	Course nr. Course name					Workloa	ad (CP)	Teaching form		HPW
	16-64-3264	vl	High-Accuracy nal Fluid Dyna	methods for Com mics	putatio-	0		Lect	ure	3
	16-64-3264	·ue	High-Accuracy nal Fluid Dyna	methods for Com mics	putatio-	0		Prac	tice	1
2	Preaching content Theory: Motivation for higher order methods; piecewise approximation by polynomials; conservative form of PDEs; flux formulation, weak form and bilinear forms; numerical fluxes; interior penalty for second order problems; time discretization; solution algorithms Computer lab: Implementation of solvers for multidimensional scalar problems of first and second order in an existing framework; Experimental examination of stability, convergence, conditioning and performance									
3	 3 Learning objectives On successful completion of this module, students should be able to: Explain fundamental properties (stability, consistency and convergence) of the Discontinuous Galerkin (DG) discretization Assess the applicability and the expectable efficiency of higher order methods for a given problem Derive the discrete form of problem statements and to implement basic solution algorithms efficiently Conduct, analyze and evaluate numerical simulations based on DG 									
4	Prerequisite for participation 1) Basic knowledge of ordinary and partial differential equations 2) Lecture Numerical Computation Methods recommended 3) Elementary programming knowledge (a.g. MATLAR, C/C) + Lawa, C#) for everying recommended									
5	Form of exa Module exa	<u>, i</u> min n:	ation	0 . 0	,		<u>, , , , , , , , , , , , , , , , , , , </u>			
	• Modul Oral exam 3	e exa 0 mi	am (Technical e in	xamination, Oral e	examinati	on, Durat	ion: 30 Min., Do	efault	RS)	
6	Prerequisite for the award of credit points Passing the examination									
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 100 %) 									
8	Usability of WPB Master WPB Master WPB Master Master Com	the MB AE PST puta	module III (Wahlfächer III Nat_Ing-Bere III (Fächer aus ttional Engineeri	aus Natur- und In ich Natur- und Ingeni ng	genieurw eurwisse	vissenscha nschaft fü	ft) r Papiertechnik))		
9	References	.141111	n							

	Di Pietro, Ern: Mathematical aspects of discontinuous Galerkin methods. Springer, 2012 Toro: Riemann solvers and numerical methods for fluid dynamics. Springer, 2009
	Lecture notes and additional study material will be made available at https://moodle.tu-darmstadt.de
10	Comment

Mo	dule name									
Ма Мо 16-9	dule nr.Credit pointsWorkloadSelf-study98-40946 CP180 h120				dy 120 h	Module durationModule c1 TermEvery 2.5			v cle emester	
Lan Ger	guage man			I	Module Prof. Dr	owner Ing. Tob	ias Melz			
1	Courses of this module									
	Course nr.Course nameWorkload							Teaching form		HPW
	16-98-4094-	vl	Machine Dyna	nics		0		Lect	ure	3
	16-98-4094-	hü	Machine Dynai	nics		0		Lect prac	ure hall tice	1
2	 Teaching content Vibration Systems in Mechanical Engineering. Problems of Advanced Machine Dynamics. Elements (parameter) of mechanical vibration systems in machines and structures. Modelling and equations of motion of linear vibration systems for machines and structures. Input-output relations, excitation and vibration response signals in the time and frequency domain. Natural vibrations of linear SDOF- and MDOF systems, eigenvalues and eigenvectors, orthogonality. Forced vibrations of linear SDOF- and MDOF systems due to different excitations. Influence of (multiphysical) interactions (structure, fluid, electric and magnetic fields) on the vibration behavior. Vibration monitoring and diagnosis. Measures for vibration control. Vibration systems with distributed parameters (continua) and nonlinear vibrations. 									
3	 3 Learning objectives On successful completion of this module, students should be able to: Work on basic problems in machine and structural dynamics and to find practical solutions. Model real mechanical vibration systems (machines and structures) and to derive the equations of motion based on the principles of mechanics. Determine and to analyse the dynamic characteristics (natural frequencies, damping behavior, vibration modes) of machines and structures. Calculate forced vibrations (system responses) of machines and structures due to different types of excitations and to interpret the solutions. Fundamentally recognize, to plan and to evaluate experimental investigations of vibration systems (frequency response, system identification, modal analysis). Plan vibration monitoring and diagnosis for machines. 									
4	Prerequisite for participation Technical Mechanics I to III (Statics, Elastomechanics, Dynamics) and Mathematics I to III recommended.									
5	 Form of examination Module exam: Module exam (Technical examination, Examination, Duration: 150 Min., Default RS) 									
6	Prerequisite Passing the e	e for exan	the award of c nination.	redit points						
7	Grading Module exar • Modul	n: e exa	am (Technical ex	xamination, Exam	ination, V	Veighting	: 100 %)			
8	Usability of	the	module							

	Master MB Ia Grundlagen Master MB SP FAS WPB Ia Pflicht WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) WI/MB, Master Mechatronik
9	References Markert, R.: "Strukturdynamik", Shaker, 2013. Dresig, H.; Holzweißig, F.: "Maschinendynamik", 10. Auflage, Springer, 2011. Gasch, R.; Nordmann, R.: "Rotordynamik", 2. Auflage, Springer,2005. Dresig, H.: "Schwingungen mechanischer Antriebssysteme", Springer 2001. Fischer, U.; Stephan, W.: "Mechanische Schwingungen", 3. Auflage, Fachbuchverlag Leipzig, 1993.
10	Comment

Mo Mat	Module name Mathematical Methods in Fluid Mechanics: Exact and Symmetry Methods									
Mo 16-	odule nr. Credit points Workload Self-st		Self-stu	1dy Module du		ion	Module cy Every 2. Se	v cle emester		
Lan	iguage				Module	owner	tin Oberlaak			
Ger 1		hic	modulo		Prol. Dr	ing. Mar	TIII ODerlack			
L	Course nr. Course name					Workloa	ad (CP)	Tea	ching form	
	16-64-5230-vl Mathematical methods in fluid mechanics Event and event methods Additional methods							Lect	ure	3
	16-64-5230-	ue	Mathematical n Exact and sym	nethods in fluid me metry methods	chanics:	0		Prac	ctice	1
2	2 Teaching content Basic equations of incompressible fluid flow; examples of exact solutions of the Navier-Stokes equations; introduction into the mathematical concept of symmetry; the theory of Lie Groups; Lies 1. and 2. fundamental theorem; dimensional analysis; invariance of differential equations; the Lie algorithm for determining symmetries; invariant solutions of non-linear partial differential equations; direct construction method of conservation laws in divergence form									
3	 3 Learning objectives On successful completion of this module, students should be able to: Simplify the complexity of the Navier-Stokes equations for various simple flow problems and reach their exact solutions. Apply the analytic theory, based on Lie symmetries, for solving ordinary and partial differential equations, especially for flow problems. Analyse the symmetries and invariances of given differential equations by means of the theory of Lie groups. Develope potential local conservation laws of differential equations with the aid of the direct 									
4	Prerequisite for participation Basic knowledge of mathematics: basic knowledge of fluid mechanics.									
5	 Form of examination Module exam: Module exam (Technical examination, Oral examination, Duration: 15 Min., Default RS) Oral exam 30 min. 									
6	 Prerequisite for the award of credit points Passing the examination 									
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 100 %) 									
8	 Usability of the module WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Angewandte Mechanik 									
9	References									

	lecture notes;
	Bluman, Kumei: Symmetries and Differential equations, Springer Verlag, 1996;
	Stephani: Differentialgleichungen, Symmetrien und Lösungsmethoden, Spektrum Akademischer Verlag, 1994;
	Cantwell: Introduction to Symmetrie Analysis, Cambridge University Press, 2002;
	Bluman, G.W., Cheviakov, A.F., and Anco, S.C.: Applications of Symmetry Methods to Partial Differential
	Equations. Applied Mathematical Sciences Vol. 168. Springer 2010.
10	Comment

Mo Mat	dule name hematical Me	etho	ds in Fluid Mee	hanics: Regular an	d Singula	r Perturba	ations			
Mo 16-	dule nr.Credit pointsWorkloadS64-32546 CP180 h		Self-stu	idy 120 h	Module duration		Module cycle Every 2. Semeste			
Lan Ger	Language GermanModule owner Apl. Prof. DrIng. Yongqi Wang									
1	Courses of	this	module							
	Course nr.		Course name	2		Worklo	ad (CP)	Теа	ching form	HPW
	16-64-3254-	vl	Mathematica nics: Regular	l Methods in Fluid and Singular Pertu	Mecha- rbations	0		Lect	ure	3
	16-64-3254-	ue	Mathematica nics: Regular	l Methods in Fluid and Singular Pertu	Mecha- rbations	0		Prac	ctice	1
2	2 Teaching content Asymptotic series and expansions; applications of the regular perturbation method in some flow problems; failure of the Poincare expansions; method of strained coordinates; renormalization technique; method of matched asymptotic expansions; flows around a sphere or a cylinder with small Reynolds numbers; method of multiple scales; turning point problems.									
3	 Learning objectives On successful completion of this module, students should be able to: 1. Explain and apply the regular perturbation method for solving differential equations, especially flow problems, by means of parameter or coordinate perturbation. 2. Recognize the limitations of the regular perturbation method. 3. Choose and apply alternative suitable singular perturbation methods if the regular perturbation method fails for given differential equations. 4. Recognize relations and distinctions of different singular perturbation methods, e.g. methods of 									
4	Prerequisite Basic knowle knowledge o	e for edge of flu	participation of ordinary ar id mechanics.	d partial differentia Knowledge of Part I	al equatio I of this le	ns and the	e corresponding ot required.	; solut	tion method	s; basic
5	 Form of examination Module exam: Module exam (Technical examination, Oral examination, Duration: 30 Min., Default RS) Oral exam 30 min. 									
6	Prerequisite for the award of credit points Passing the examination									
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 100 %) 									
8	Usability of WPB Master WPB Master Angewandte	the MB PST Me	module III (Wahlfäche III (Fächer au chanik	r aus Natur- und In s Natur- und Ingen	igenieurw ieurwisse	vissenscha nschaft fü	ft) r Papiertechnik)		
9	References lecture note Methods in I	s; N Fluic	ayfeh, A.H.: P l Mechanics, P	erturbation Methoo arabolic Press, 1975	ds, John 5.	Wiley & S	Sons, 1975; Var	n Dyk	e, M.: Pertu	ibation
10	Comment									

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Mo Mu	dule name Itiphase Flows	5								
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Mo	dule nr. 64-5220	Cr	edit points 6 CP	Workload 180 h	Self-study 120 h		Module durat	tion	Module cy Every 2. Se	v cle emester
Lan Ger	guage man	1		1	Module Apl. Pro	e owner of. DrIng	. Yongqi Wang			
1	Courses of	his	module							
	Course nr.		Course name			Worklo	ad (CP)	Tea	ching form	HPW
	16-64-5220-vlMultiphase Flows16-64-5220-ueMultiphase Flows					0		Lect Prac	ture tice	3
2	2 Teaching content Kinematics; continuum mechanical modeling of the balance laws for immiscible multiphase flows with phase interfaces; jump conditions at phase interfaces and interfacial transport equations; particle-laden flows with the Euler-Langrange description; balance equations for miscible multicomponent mixtures; diffusion processes; some simple examples.									
3	 Learning objectives On successful completion of this module, students should be able to: 1. Explain the fundamental balance equations for the continuum-mechanical description of immiscible multiphase flows with phase interfaces, particle-laden flows and miscible multicomponent mixtures and to comprehend and to describe the associated flow physics. 2. Apply the approach of mathematical description and modeling to simple flow problems from various fields of multiphase and multicomponent flows. 3. Explain the behaviour of immiscible multiphase flows and mixtures for simple applications by means of balance relations. 4. Distinguish restrictions of various modelling methods. 									
4	Prerequisite 1) Fluid Mee 2) Ordinary 3) Continuu	e for chan and m M	participation hics or Technical partial different lechanics, advan	Mechanics IV reco ial equations; tageous but not re	ommende equired	d;				
5	Form of exa Module exar • Modul Oral exam 3	min n: e ex 0 m	n ation am (Technical ex in.	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	t RS)	
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points						
7	Grading Module exar • Modul	n: e ex	am (Technical ex	xamination, Oral 6	examinati	on, Weigl	nting: 100 %)			
8	Usability of WPB Master WPB Master	the MB PST	module III (Wahlfächer III (Fächer aus	aus Natur- und In Natur- und Ingeni	genieurw eurwisse	rissenscha nschaft fü	lft) ir Papiertechnik)		
9	References Lecture Note	es								
10	Comment									

Mo	dule name deling of Turl	ouler	nt Flows									
Mo 16-	dule nr. 71-3024	Cro	edit points 8 CP	Workload 240 h	Self-stu	ı dy 150 h	Module durat	ion	Module cy Every 2. Se	v cle emester		
Lan Eng	i guage lish				Module owner Prof. DrIng. Christian Hasse							
1	Courses of	this	module									
	Course nr.		Course name			Workload (CP)		Teaching form		HPW		
	16-71-3024-	vl	Modeling of Tu	rbulent Flows		0		Lect	ure	4		
	16-71-3024-	·ue	Modeling of Tu	rbulent Flows		0		Prac	ctice	2		
2	2 Teaching content Continuum mechanics (transport equations), basics of turbulence (properties, mathematical basics, time and length scales, spectral perspective), statistical turbulence modeling(RANS), Direct Numerical Simulation, Large Eddy Simulation (filtering, modeling, dynamic models, choice of model).											
	 On successful completion of this module, students should be able to: 1. Describe transient flow phenomena and their forms of appearance. 2. Explain the mathematical background and flow parameters of turbulence. 3. Derive the describing governing equations as well as their modeled form and interpret them by means of fundamental types of flows. 4. Recognize and characterize the most important types of technical flows. 5. Depict the dynamics of turbulent flows and elucidate the mathematical methods for their description. 6. Describe the fundamental models within modern flow solvers, apply them correctly, and assess their results. 7. Explain the resolution requirements of the Direct Numerical Simulation and therewith estimate its resource demands for high performance computers. 8. Elucidate and apply the fundamentals and modeling approaches of the Large Eddy Simulation. 											
4	Prerequisite Fundamenta	e for al Flu	participation aid Mechanics re	commended								
5	Form of exa Module exa • Modul Written exa	min m: e exa n 90	ation am (Technical ex min or oral exa	xamination, Oral/ m 20 min	written e	xaminatio	on, Default RS)					
6	Prerequisit Passing the	e for exan	the award of c nination	redit points								
7	Grading Module exan • Modul	m: e exa	am (Technical ex	amination, Oral/	written ez	xaminatic	on, Weighting: 1	.00 %)			
8	Usability of WPB Master Master AE II Master MB I WPB Master	the MB Ker I SP PST	module II (Kernlehrvera nlehrveranstaltu CEPE ' III (Wahlfächer	nstaltung aus den ng aus Natur- und Ir	n Maschii ngenieurv	nenbau) vissenscha	aft)					
9	References Lecture slide in the lectur	es an e.	d a german vide	otaping will be ma	ade availa	ble via M	oodle. Further li	iterat	ure will be o	utlined		
10	Comment											

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Mo Nat	dule name	fluid	lics I							
Mo 16-	dule nr. 15-5190	Cr	edit points 4 CP	Workload 120 h	Self-stu	l dy 75 h	Module dura 1 Term	tion	Module cycle Winter term	
Lar Ger	i guage man	1		I	Module Prof. Dr	owner . rer. nat.	Steffen Hardt		1	
1	Courses of	this	module							
	Course nr.		Course name			Worklo	ad (CP)	Tea	ching form	HPW
	16-15-5190-	vl	Nano- and Mic	rofluidics I		0		Lect	ure	2
	16-15-5190-	ue	Nano- and Mic	rofluidics I		0		Prac	ctice	1
2	Teaching content1. Fundamental equations of continuum fluid dynamics2. Pressure-driven flow3. Electrokinetic flow4. Molecular dynamics5. Experimental characterization of micro flows6. Applications									
3	 Learning objectives On successful completion of this module, students should be able to: Compute elementary flow fields of pressure-driven and electrokinetic flow. Design simple microfluidic hydraulic networks. Identify the limits of continuum models for liquids. Explain the fundamentals and the limits of the molecular dynamics method. Formulate simple models for the configuration and dynamics of polymers based on the principle of entropy maximization. Explain the fundamentals and the limits of the Micro-Particle-Image-Velocimetry method. Formulate elementary microfluidic design concepts based on micropumps, micromixers and microreactors. 									
4	Prerequisite Basic knowle	e for edge	participation of fluid dynamic	cs and heat and m	ass trans	port				
5	Form of exa Module exa • Modul Oral exam 3	min n: e ex 0 m	aation am (Technical ex in	amination, Oral e	examinati	on, Durat	ion: 30 Min., D	efaul	t RS)	
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points						
7	Grading Module exan • Modul	n: e ex	am (Technical ex	camination, Oral e	examinati	on, Weigł	nting: 100 %)			
8	Usability of WPB Master WPB Master Master Mech	the MB PST natro	module II (Kernlehrvera III (Fächer aus T onik	nstaltung aus der Natur- und Ingeni	n Maschin leurwisser	nenbau) nschaft fü	r Papiertechnik	c)		
9	References Will be anou	ince	d in the lecture							
10	Comment									

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Mo Nai	dule name	fluid	lics II									
Mo 16-	dule nr. 15-5220	Cr	edit points 4 CP	Workload 120 h	Self-stu	i dy 75 h	Module durat	ion	Module cycle Every 2. Semester			
Lar Ger	n guage man				Module owner Prof. Dr. rer. nat. Steffen Hardt							
1	Courses of	this	module									
	Course nr.		Course name			Worklo	ad (CP)	Теа	ching form	HPW		
	16-15-5220-	-vl	Nano- and Mic	rofluidics II		0		Lecture		2		
	16-15-5220-	20-ue Nano- and Microfluidics II					0 Practice					
2	1. Gas kinetics 2. Interfacial flows 3. Particulate flows 4. Dispensing systems 5. Cooling systems 6. Droplet manipulation 7. Particle separation											
5	 Learning objectives On successful completion of this module, students should be able to: Explain how the dynamics of gases on the submicron scale is different from the corresponding macroscopic dynamics. Explain how important physical phenomena play a role in interfacial flows on the micro- and nanoscale. Identify the most important mechanisms that are important for the transport of micro and nanoparticles. Develop design concepts of dispensing systems meeting specific requirements. Develop design concepts for droplet-based microfluidic systems meeting specific requirements. Jentify suitable methods for particle separation meeting specific requirements. 											
4	Prerequisite Basic knowle	e for edge	participation of fluid dynami	cs and heat and m	ass trans	port.						
5	Form of exa Module exan • Modul Oral exam 3	a min m: .e exa 0 mi	a ation am (Technical ex in	xamination, Oral 6	examinati	on, Durat	tion: 30 Min., D	efault	RS)			
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points								
7	Grading Module exan • Modul	m: e ex	am (Technical ex	xamination, Oral e	examinati	on, Weigl	nting: 100 %)					
8	Usability of WPB Master WPB Master	the MB PST	module II (Kernlehrvera III (Fächer aus	instaltung aus der Natur- und Ingeni	n Maschir eurwisser	nenbau) nschaft fü	ir Papiertechnik)				
9	References Will be anno	ounc	ed in the course.									

10	Comment

Mo	dule name nlinear Dynan	nics								
Mo 16-	dule nr. 25-5160	Cr	edit points 6 CP	Workload 180 h	Self-stu	dy 120 h	Module durat 1 Term	tion	Module cy Every 2. Se	v cle emester
Lar Ger	n guage man				Module Prof. Dr.	owner -Ing. Ber	nhard Schweize	er		
1	Courses of	this	module							
	Course nr.		Course name			Worklo	ad (CP)	Teaching form HP		HPW
	16-25-5160-	vl	Nonlinear Dyna	amics		0		Lecture 3		3
	16-25-5160-	·ue	Nonlinear Dyna	amics		0		Prac	tice	1
2	 2 Teaching content Introduction into Nonlinear Dynamics; Stability Theory of Dynamical Systems; Bifurcations of Stationary Solutions; Chaos; 									
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Classify and describe nonlinear phenomena of dynamical systems. 2. Calculate the stability of equilibrium and periodic solutions. 3. Represent the different types of bifurcations. 4. Identify chaos and describe the routes into chaos. 5. Investigate nonlinear dynamical systems by means of stability and bifurcation theory. 									
4	Prerequisite for participation									
5	Form of exa Module exa • Modul Written exa	min m: e ex n (1	aation am (Technical ex 20 min) or oral o	xamination, Oral/ exam (30 min): A	written ex greement	caminatio at the be	n, Default RS) ginning of the l	ecture	2	
6	Prerequisit Passing the	e for exan	the award of c nination	redit points						
7	Grading Module exan • Modul	m: e ex	am (Technical ex	xamination, Oral/	written ex	kaminatio	n, Weighting: 1	.00 %))	
8	Usability of WPB Master WPB Master Sonstige Stu	the MB PST	module III (Wahlfächer III (Fächer aus ngänge: WI/MB,	aus Natur- und In Natur- und Ingeni Mechatronik, ETI	genieurw eurwissei T	issenscha 1schaft fü	ft) r Papiertechnik)		
9	References (1) Hagedon (2) Nayfeh, (3) Argyris, (4) Magnus, von Schwing (5) Greiner, (6) Schuster Comment	rn, P A.H. J.; F K.; P gung W.: ; H.	.: "Nichtlineare S ; Mook D.T.: "No aust, G.; Haase, J opp, K.; Sextro, V gen", Springer Vie "Klassische Mech G.: "Determinist	Schwingungen", A onlinear Oscillatio M.: "An Exploratio V.: "Schwingunger eweg, Wiesbaden, nanik II", Verlag H isches Chaos: eine	kademisc ns", Wiley on of Cha 1: Physika 2013. 2013. 2arri Deut Einführu	he Verlag 7-Interscie os", Nortl lische Gru sch, Fran ıng", VCH	sgesellschaft, W ence, Reprint Ed n Holland, 1994 Indlagen und ma kfurt, 2008. I, Weinheim, 19	/iesba lition, l. uthema 994.	den, 1978. 1995. atische Beha	ndlung

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Mo Cor	dule name nputational A	erod	lynamics									
Mo	dule nr.	Cro	edit points	Workload	Self-stu	dy	Module durat	tion	Module cy	vcle		
Lan	iguage		0 CP	100 11	Module	owner	1 101111		Every 2. Se	emester		
Ger	man				Apl. Pro	. Prof. DrIng. Suad Jakirlic						
1	Courses of	this	module			Worklow	od (CD)	Тор	ahing form			
	Course III.		Course name	WORK			au (CP)	Tea	ching form	HPW		
	16-11-5091-	vl	Computational	Aerodynamics		0		Lect	ure	3		
2	2 Teaching content Overview of computational approaches for fluid mechanics (panel method, boundary-layer methods, Euler codes, Navier-Stokes codes), discretisation methods (for complex and irregular geometries), treatment of compressible flows (artificial compressibility, pressure-velocity-density coupling); treatment of shocks (total variation diminishing - difference techniques); boundary conditions (pressure, total state, supersonic outflow); transition, turbulence modelling (statistical models); wall treatment (modelling and exact treatement)											
3	 3 Learning objectives On successful completion of this module, students should be able to: Explain and apply the methods for numerical discretization of transport equations of fluid mechanics (and heat transfer). Explain and systematically apply the mathematical models aiming at capturing of the physics of compressible, turbulent flows with relevance to aircraft aerodynamics. Analyse and interpret the results of the practical computations of a large number of the flow configurations subjected to different extra strain rates. 											
4	Prerequisite Fluid Mecha	e for nics	participation and Numerical	Methods in Mecha	nical Eng	ineering	recommended.					
5	Form of exa Module exan • Modul Oral exam 4	n min n: e exa 5 mi	ation am (Technical e: in	xamination, Oral e	examinati	on, Durat	ion: 45 Min., D	efault	RS)			
6	Prerequisit Passing the	e for exan	the award of c nination	redit points								
7	Grading Module exan • Modul	n: e exa	am (Technical e	xamination, Oral e	examinati	on, Weigł	nting: 100 %)					
8	Usability of WPB Master WPB Master	the MB PST	module III (Wahlfächer III (Fächer aus	aus Natur- und In Natur- und Ingeni	genieurw eurwissei	issenscha 1schaft fü	ft) r Papiertechnik)				
9	 References Lecture notes can be obtained as PDF. ANDERSON, J. (1988): Aerodynamics, McGraw-Hill, NY. HIRSCH, Ch. (1988): Numerical Computation of Internal and External Flows I and II, John Wiley and Sons. CEBECI, T. (1999): An Engineering Approach to the Calculati. FERZIGER, J.H., PERIC, M.P. (1999): Computational Methods for Fluid Dynamics, Springer Verlag 											
10	Comment											

Mo Nui	dule name nerical Metho	ods of	f Applied Dynar	nics							
Mo 16-	dule nr. 25-5150	Cre	edit points 6 CP	Workload 180 h	Self-stu	dy 120 h	Module durat	tion	Module cycle Every 2. Semester		
Lar Ger	i guage man	1		1	Module Prof. Dr	lle owner DrIng. Bernhard Schweizer					
1	Courses of	this r	module		I						
	Course nr.		Course name			Workloa	ad (CP)	Teaching form		HPW	
	16-25-5150- 16-25-5150-	·vl ·ue	Numerical Met Numerical Met	hods of Applied D hods of Applied D	ynamics vnamics	0		Lecture		3	
2	2 Teaching content Time integration methods (one-step/multistep methods) for the numerical solution of ordinary differential equations (ODE-systems); Introduction in the theory of Differential-Algebraic Equations (DAE-systems); Numerical methods for the solution of DAE-systems.										
3	 3 Learning objectives On successful completion of this module, students should be able to: Mathematically describe the different methods for the numerical integration of ordinary differential equations (ODE). Judge the stability and the accuracy of the numerical integration methods. Formulate the differential algebraic equations (DAEs) of different indices for complex dynamical systems. Mathematically describe and evaluate the different methods for the numerical integration of differential algebraic equations (DAEs). Anthematically describe and evaluate the different methods for the numerical integration of differential algebraic equations (DAEs). Apply the mathematical principles for the computer-aided simulation of dynamical systems in practial problems. 										
4	Prerequisite	e for	participation								
5	Form of exa Module exar • Modul Written exar Will be anno etc.).	a mina m: e exa m (12 unceo	ation am (Technical e: 20 min) or oral d at the beginnin	xamination, Oral/ exam (30 min). ng of the term depe	written e: ending on	xaminatio the circu	n, Default RS) mstances (numb	per of	students, par	ndemic	
6	Prerequisite Passing the e	e for exam	the award of c ination	redit points							
7	Grading Module exan • Modul	m: e exa	am (Technical e	xamination, Oral/	written ez	kaminatio	n, Weighting: 1	00 %)		
8Usability of the moduleWPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)Sonstige Studiengänge: WI/MB, Mechatronik, ETIT											
9	References										

	(1) Eich-Soellner, E.; Führer, K.: "Numerical Methods in Multibody Dynamics", Teubner, 1998.	
	(2) Hairer E., Wanner G.: "Solving Ordinary Differential Equations I and II", Springer Verlag.	
	(3) Jalon, G.; Bayo, E.: "Kinematic and Dynamic Simulation of Multibody Systems", Springer, 1994.	
	(4) Schwarz, H.; Köckler, N.: "Numerische Mathematik", 8. Auflage, Teubner, 2004.	
	(5) Simeon, B.: "Computational Flexible Multibody Dynamics", Springer, 2013.	
1	Comment	

Mo	Iodule name											
Mo	dule nr.	Cre	edit points	Workload	Self-stu	dy	Module durat	ation Module c		vcle		
10- Lar	11-5141 0011200		0 CP	180 h	Module							
Ger	man				Apl. Pro	Prof. DrIng. Suad Jakirlic						
1	Courses of	this	module							1		
	Course nr.		Course name			Workloa	ad (CP)	Teaching form		HPW		
	16-11-5141-	vl	Computational Processes in Flu	l Modelling of Tr uids	ansport	0		Lect	ure	3		
2	2 Teaching content Reynolds stress models (derivation and modelling), linear and non-linear eddy viscosity models, algebraic Reynolds stress models, multi-scale models, low Re modelling and wall effects, advanced wall treatment, turbulent mixing under the conditions of variable flow properties, multiphase flows, direct numerical simulation (DNS) and large eddy simulation (LES), hybrid turbulence models, application examples											
3	 3 Learning objectives On successful completion of this module, students should be able to: Derive the physical/mathematical models for numerical description and analysis of turbulent flows and associated transport processes like heat and mass transfer for single and multi-phase flows for the purpose of numerical simulation. Describe the turbulent flows and associated transport processes computationally (with respect to a complementary simulation) and to become familiar with the possibilities about their analytical treatment. Apply the methods of computational modelling by the design of thermo-fluid apparatus. 											
4	Prerequisite Fluid Mecha	e for nics	participation and Numerical J	Methods in Mecha	inical Eng	ineering 1	recommended.					
5	Form of exa Module exa • Modul Oral exam 4	n min n: e exa 5 mi	a tion am (Technical ez in	xamination, Oral ε	examinati	on, Durat	ion: 45 Min., D	efault	RS)			
6	Prerequisite Passing the	e <mark>for</mark> exan	the award of c nination	redit points								
7	Grading Module exan • Modul	n: e exa	am (Technical ez	xamination, Oral e	examinati	on, Weigh	nting: 100 %)					
8	Usability of WPB Master WPB Master	the MB PST	module III (Wahlfächer III (Fächer aus	aus Natur- und In Natur- und Ingeni	genieurw eurwisse	issenscha nschaft fü	ft) r Papiertechnik)				
9	References Lecture note POPE, S. (20 HANJALIC, 1 HANJALIC, 1	es ca: 000) K. (2 K. ar	n be obtained as : Turbulent Flow 2004): Closure M nd JAKIRLIC, S.	PDF; /s, Cambridge Uni lodels for incomp (2002): Second-M	versity Pr ressible tu toment Tu	ess; irbulent fl irbulence	ows. VKI lectur	e note	25;			
10	Comment											

Mo N111	Module name Numerical Simulation of Flows										
Mo 16-	dule nr. 19-5020	Cr	edit points 6 CP	Workload 180 h	Self-stu	l dy 120 h	Module durat	tion	Module cy Winter terr	v cle m	
Lar Ger	guage man			I	Module DrIng.	e owner Florian K	lummer				
1	Courses of t	his	module		0						
-	Course nr.		Course name			Worklo	ad (CP)	Теа	ching form	HPW	
	16-19-5020- 16-19-5020-	vl ue	Numerical Sim	ulation of Flows ulation of Flows		0		Lect Prac	ure tice	3	
2	 2 Teaching content Basics of continuum mechanical flow modelling; numerical grids; grid generation; finite-volume methods for complex geometries; finite-volume methods for incompressible flows; upwind methods; flux-blending; pressure-correction methods; numerical methods for turbulent flows; basics of statistical turbulence modelling; k-eps model; sparse linear and nonlinear system solvers; ILU methods; conjugate gradient methods; preconditioning; multigrid methods; parallel computing. Result Learning objectives 										
3	Inductive methods, parameter computing. Learning objectives On successful completion of this module, students should be able to: 1. Explain the basics of continuum mechanical flow modelling. 2. Explain the properties of numerical grids and to apply important methods for their generation. 3. Apply finite-volume methods to complex geometries. 4. Apply finite-volume methods for the simulation of incompressible flows. 5. Describe upwind methods, flux-blending methods, and pressure-correction methods and explain their functionality. 6. Explain general approaches for the computation of turbulent flows using statistical turbulence modelling. 7. State the most important methods for the solution of sparse linear and nonlinear systems and estimate their efficiency. 8. Describe the principles of multigrid methods and of parallel computing.										
4	Prerequisite Numerical M	e for Iath	participation ematics and Nun	nerical Methods re	ecommen	ded					
5	Form of exa Module exa • Modul Oral exam 3	min n: e ex 0 m	aation am (Technical ex	xamination, Oral 6	examinati	on, Durat	ion: 30 Min., D	efault	ERS)		
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points							
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 100 %) 										
8	Usability of WPB Master Master MB I WPB Master Master Mech	the MB I SP PST natro	module II (Kernlehrvera CEPE III (Fächer aus pnik	instaltung aus der Natur- und Ingeni	n Maschir ieurwisser	nenbau) nschaft fü	r Papiertechnik)			
9	References										

	Schäfer, Numerik im Maschinenbau, Springer, 1999; Exercises in WWW; Schäfer, Numerical Methods in Engineering, Springer, 2006
10	Comment

Mo Adv	Module name Advanced Methods for Flow Simulation										
Mo 16-	dule nr. 19-5100	Cre	edit points 4 CP	Workload 120 h	Self-stu	1 dy 90 h	Module durat 1 Term	tion	Module cy Every 2. Se	y cle emester	
Lan Ger	iguage man/English				Module Prof. Di	owner . rer. nat.	Michael Schäfe	r			
1	Courses of t	this 1	module								
	Course nr.		Course name		Workload (CP)			Teaching form		HPW	
	16-19-5100-	vl	Advanced Met	nods for Flow Sim	ulation	0		Lect	ure	2	
2	2 Teaching content Introduction. Algebraic Multi Grid methods. Free surface simulation (Volume-of-Fluid / Level Set Methods). Si- mulation of multi-physics (per instance Fluid-Structure-Interaction, flow-acoustic-coupling). Selected advanced topics (e. g. Lattice-Boltzmann-methods, alternative discretization techniques).										
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Describe the considered advanced methods for numerical flow simulation. 2. Explain the basic principles, equations, and properties of the considered methods. 3. Correctly assess the considered methods with respect to assets and drawbacks when applied to concrete flow problems. 										
4	Prerequisite Content of le	e for ectur	participation e "Numerical Si	mulation of Flows'	1						
5	Form of exa Module exar • Modul Oral exam 2	mina m: e exa 5 min	ation am (Technical e: n	xamination, Oral e	examinati	on, Durat	ion: 25 Min., D	efault	RS)		
6	Prerequisite Passing the e	e for exam	the award of c	redit points							
7	Grading Module exar • Modul	m: e exa	am (Technical e:	xamination, Oral e	examinati	on, Weigl	nting: 100 %)				
8	Usability of WPB Master WPB Master	the MB PST	module III (Wahlfächer III (Fächer aus	aus Natur- und In Natur- und Ingeni	genieurw eurwisse	vissenscha nschaft fü	ıft) ir Papiertechnik	.)			
9	References a	at the	e beginning of th	ne lecture.							
10	0 Comment										

Mo Mat	Module name Materials Science IV: Mechanical Properties										
Mo 11-	dule nr. 01-1031	Credit points 6 CP	Workload 180 h	Self-stu	l dy 120 h	Module dura 1 Term	Ation Module cycle Every 2. Semest		v cle emester		
Lan Ger	n guage man			Module Prof. Dr	Module owner Prof. DrIng. Jürgen Rödel						
1	Courses of t	his module									
	Course nr.	Course name		Workload (CP)		Teaching form		HPW			
	11-01-1027-vl Materials Science IV				0		Lect	ure	3		
	11-01-1027-	ue Exercise Course	e Materials Scienc	e IV	0		Prac	tice	1		
2	Teaching co	ntent									
3	3 Learning objectives										
4	Prerequisite	e for participation									
5	Form of exa Module exar • Module	mination n: e exam (Technical ex	amination, Oral/v	written e	xaminatic	n, Default RS)					
6	Prerequisite Passing the f	e for the award of c	redit points ation								
7	Grading Module exar • Module	n: e exam (Technical ex	amination, Oral/v	written e:	xaminatic	n, Weighting: 1	00 %)			
8	Usability of the module										
9	References										
10	Comment										

Mo Mic	Module name Micromechanics for Materials Science										
Mo 11-0	dule nr. 01-4109	Cre	edit points 6 CP	Workload 180 h	Self-stu	Self-study Module dur 135 h 1 Term			Module cy Every 2. Se	v cle emester	
Lan Eng	l guage lish	I			Module Prof. Ph	e owner . D. Bai-X	iang Xu				
1	Courses of t	this	module								
	Course nr.		Course name			Workloa	ad (CP)	Теас	hing form	HPW	
	11-01-7050-	vl	Micromechanic	s for Materials Sci	ience	0		Lecture		2	
	11-01-7050-	ue	Exercises in Mic Science	cromechanics for N	laterials	0		Prac	tice	1	
2	Teaching co This lecture Important to gurational fo modeling.	deal opics orce,	nt ls with fundame s include: Basics , micro-macro tr	ntals of micromec of elasticity, defe ransition and hon	hanics in ect mecha nogenizat	the fram mics, plas tion, phas	ework of elastic sticity, crystal p se-field theory, a	rity an lastici and p	d plasticity ty, theory o hase-field fi	theory. f confi- racture	
3	Learning objectives The successful students can interpret the elastic and plastic behavior of a material using the continuum theory, and describe the stress situation around certain a microstructure, e.g. at crack tips and near defects. They can also apply the basic concept of homogenization to calculate the effective properties of heterogeneous materials. They have the competence to follow advanced textbooks and scientific literature on nonlinear continuum mechanics and composite mechanics.										
4	Prerequisite for participation recommended: basics of mathematics and elastomechanics										
5	Form of exa Module exar • Module Written exan The form of	min n: e exa n (1) exan	ation am (Technical ex 20 min), oral ex nination will be	xamination, Oral/v am (30 min), or ro specified within ty	written ez emote ex wo weeks	xaminatio am (open after the	n, Default RS) book) 120 min first lecture.				
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points							
7	Grading Module exar • Module	n: e exa	am (Technical ex	xamination, Oral/v	written e:	xaminatio	n, Weighting: 1	00 %))		
8	Usability of	the	module								
9	References 1. Cai W., & W.D. Nix; Imperfections in Crystalline Solids, Cambridge, 2016 2. Gross D., Seelig T.; Fracture Mechanics with an Introduction to Micromechanics, 3. 2nd Edi. 2011 4. Le, Khan Chau; Introduction to Micromechanics, Nova Science Publ, 2010 5. Mura, T.; Micromechanics of Defects in Solids, Martinus Nijho_ Publishers 1982 6. Zohdi T.I., &Wriggers P.; An Introduction to Computational Micromechanics, Springer, 2004 7. Weertman, J.; Dislocation based fracture mechanics, World Scienti_c 1996 8. Provatas, N., Elder, K.; Phase-Field Methods in Materials Science and Engineering, 9. Wiley-VCH Verlag GmbH & Co. KGaA, 2010										
10	Comment										

Cycle: each winter semester

3 Elective Area B: Advanced Modules in Mathematics

Mo Cor	Iodule name Complex Analysis										
Mo 04-	dule nr. C 10-0226/en	credit points 5 CP	Workload 150 h	Self-stu	dy 105 h	Module durat 1 Term	tion Module cycle Every 2. Semester				
Lar Eng	iguage glish			Module Prof. Dr.	owner rer. nat.	Matthias Hiebe	r				
1	Courses of this	s module									
	Course nr.	Course name			Worklo	ad (CP)	Teachi	ng form	HPW		
	04-00-0225-vu	Complex Analy	sis		0		Lectur practic	e and e	3		
2	 2 Teaching 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. 										
3	Learning objectivesStudents- 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	Prerequisite for participation recommended: Analysis and Linear Algebra										
5	Form of examination Module exam: • Module exam (Study achievement, Special form, p/np RS) • Module exam (Technical examination, Oral/written examination, Duration: 60 Min., Default RS) 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										
6	Prerequisite fo Passing the Fac Passing the Stu	or the award of c hprüfung; dienleistung is a p	r edit points prerequisite for tal	king the F	Fachprüfu	ng					
7	Grading Module exam: • Module ex • Module ex	xam (Study achie xam (Technical ex	vement, Special fo	orm, Weig written ex	hting: 0 (%) on, Weighting: 1	00 %)				
8	Usability of the B.Sc. Mathema	e module tik, LaG Mathema	tik								
9	References Freitag: Funktio Remmert: Funk Conway: Functi	onentheorie I, Spr ktionentheorie I ions of one comple	inger ex variable, Sprinş	ger							
10	Comment										

recommended: Mathematics: Bachelor year 2, Teaching Degrees

Mo Dif	Module name Differential Geometry											
Mo	dule nr. 10-0507/en	Cr	edit points 9 CP	Workload 270 h	Self-stu	dy 180 h	Module durat	tion	Module cycle			
Lar	iguage glish		,		Module Prof. Dr	Module owner Prof. Dr. rer. nat. Elena Mäder-Baumdicker						
1	Courses of	his	module									
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW		
	04-10-0507-vu Differential Geometry							Lect prac	ure and tice	6		
2	2 Teaching 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	3 Learning objectives 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	Prerequisite for participation recommended: Analysis, Ordinary Differential Equations, Linear Algebra											
5	 Form of examination Module exam: Module exam (Study achievement, Special form, p/np RS) Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) 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 											
6	Prerequisite Passing the Passing the S	e for Fach Stud	the award of c prüfung; ienleistung is a j	redit points prerequisite for tal	king the F	Fachprüfu	ng					
7	Grading Module exar • Modul • Modul	n: e ex e ex	am (Study achie am (Technical ez	vement, Special fo	orm, Weig written ez	hting: 0 s kaminatio	%) n, Weighting: 1	.00 %))			
8	Usability of B.Sc. Mathe	the mati	module k, M.Sc Mathem	atik, M.Sc. Mathe	matics, L	aG Mathe	ematik					
9	References Bär: Elemen Montiel, Ros Hoschek, La	tare : Cu sser:	Differentialgeor rves and surface Grundlagen der	netrie es r Geometrischen D	Datenvera	rbeitung						
10	 Comment recommended: Mathematics: Bachelor year 3 (geo), Teaching Degrees 											

Mo Inti	Module name Introduction to Mathematical Modelling									
Mo 04-	dule nr. 10-0044/de	Cr	edit points 5 CP	Workload	Self-stu	i dy 90 h	Module durat	tion	Module cy Every 4. Se	z cle
Lar	iguage			100 11	Module	e owner	Jens Lang		2.019 11 00	
1	Courses of t	his	module		1101121		00110 20116			
-	Course nr.		Course name			Worklo	ad (CP)	Teaching form		HPW
	04-00-0140-	vu	Introduction to	Mathematical Mo	odelling	0	ire and ice	4		
2	Teaching co basic concep systems with	onte ts, si n opj	nt tatical linear, nor ponent, random.	n-linear and discre	te system	s, dynami	cal systems in o	ne and	more dime	ensions,
3	Learning of Students un particular so The students	ject ders lutic are	tives tand and are abl on concepts for ex able to apply kn	e to apply the basi cemplary applications own modeling tech	ic techniq ons and u hniques to	ues of ma nderstand o further a	thematical mod l the underlying applications and	leling. mathe to inte	They are av ematical strue erprete the p	ware of uctures. results.
4	Prerequisite for participation recommended: Analysis, Linear Algebra									
5	 Fercommended: Analysis, Linear Algebra Form of examination Module exam: Module exam (Study achievement, Special form, p/np RS) Module exam (Technical examination, Oral/written examination, Duration: 60 Min., Default RS) 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	Prerequisite Passing the Passing the State	e for Fach Stud	the award of c prüfung; ienleistung is a j	redit points prerequisite for tab	king the I	Fachprüfu	ng			
7	Grading Module exar • Modul • Modul	n: e exa e exa	am (Study achie am (Technical ez	vement, Special fo camination, Oral/	orm, Weig written e	ghting: 0 G xaminatio	%) n, Weighting: 1	.00 %)		
8	Usability of B.Sc. Mathe	the mati	module k, LaG Mathema	ntik						
9	References lecture notes	5								
10	Comment recommended: Mathematics: Bachelor year 3, Teaching Degrees									

Mo Intr	Iodule name										
Mo 04-	dule nr. 10-0040/de	Cr	edit points 9 CP	Workload 270 h	Self-stu	l dy 180 h	Module durat 1 Term	tion	Module cy Every 2. Se	v cle emester	
Lar Gei	iguage man	1		I	Module Prof. Dr	owner rer. nat.	Marc Pfetsch	I			
1	Courses of	this	module								
	Course nr.		Course name			Worklo	ad (CP)	Teach	ning form	HPW	
	04-00-0023-	vu	Introduction to	Optimization		0		re and ice	6		
2	2 Teaching 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	 Learning objectives Students are proficient in optimality and duality theory in linear optimization. are familiar with the basics of the theory of polyedra and convex functions know basic numerical methods for the solution of linear and quadratic optimization problems. are able to solve and model applications with linear and quadratic optimization problems. 										
4	4 Prerequisite for participation recommended: Analysis, Linear Algebra										
5	 recommended: Analysis, Linear Algebra Form of examination Module exam: Module exam (Study achievement, Special form, p/np RS) Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) 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. 										
	Studienleist the homewo communicat	ung: rk a ed b	: Usually this r ssignments. The by the instructor	neans that the s precise proportior during the first lea	student s n of neces cture.	uccessful sary assig	ly completes and the	a certa markii	in proport ng scheme	ion of will be	
6	Prerequisite Passing the Passing the Pas	e for Fach Stud	the award of c prüfung ; ienleistung is a j	redit points prerequisite for tal	king the F	Fachprüfu	ng				
7	 7 Grading Module exam: Module exam (Study achievement, Special form, Weighting: 0 %) Module exam (Technical examination, Oral/written examination, Weighting: 100 %) 										
8	Usability of B.Sc. Mathe	the mati	module k, M.Sc Mathem	atik, M.Sc. Mathe	matics, L	aG Mathe	ematik				
9	References										

1	Chyatal: 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

Mo Fur	Module name Functional Analysis										
Mo 04-	dule nr. 10-0036/de	Cr	edit points 9 CP	Workload 270 h	Self-stu	Self-study Module d 180 h 1 Term		tion	Module cy Every 2. Se	v cle emester	
Lar Ger	iguage man	1			Module Prof. Dr	owner rer. nat.	Matthias Hiebe	r			
1	Courses of	this	module								
	Course nr.		Course name			Workloa	ad (CP)	Teac	hing form	HPW	
	04-00-0069-	vu	Functional Ana	lysis		0		Lectu pract	ure and tice	6	
2	2 Teaching 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	 3 Learning objectives 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	Prerequisite for participation recommended: Analysis, Integration Theory, Complex Analysis, Linear Algebra or comparable prerequisites acquired in mathematics courses in engineering programmes										
5	Form of exa Module exan • Modul • Modul Fachprüfung potential par form of the o during the fi	min n: e ex e ex : Us rticip exan rst t	am (Study achie am (Technical ex ually the exam is pants. In this case n is taken and co wo weeks of the Usually this r	vement, Special for camination, Oral/ taken in form of a e, the exam can be mmunicated lecture, based on neans that the s	orm, p/np written ex a written t e taken in the prosp	RS) caminatio cest, excep the form pective nu uccessful	on, Duration: 90 ot when there ar of an oral exam mber of studen ly completes a	Min., re only n. The ts taking	Default RS a small nur decision ab ng the exan) nber of out the n. tion_of	
	the homewo communicat	rk a rk b	signments. The oy the instructor	precise proportion during the first lea	n of neces	sary assig	nments and the	marki	ing scheme	will be	
6	Prerequisite Passing the Passing the Pas	e for Fach Stud	the award of c prüfung ; ienleistung is a p	redit points prerequisite for tal	king the F	achprüfu	ng				
7	 7 Grading Module exam: Module exam (Study achievement, Special form, Weighting: 0 %) Module exam (Technical examination, Oral/written examination, Weighting: 100 %) 										
8	Usability of B.Sc. Mathe	the mati	module ik, M.Sc Mathem	atik, M.Sc. Mathe	ematics						
9	References										

	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)

Mo Dise	Module name Discontinuous Galerkin Methods											
Mo	dule nr.	Cr	edit points	Workload	Self-stu	dy	Module durat	ion	Module cycle			
04-	10-0395		6 CP	180 h	120 h 1 Term Every 9. Semeste							
Ger	man/English				Prof. Dr	rer. nat.	Jan Giesselman	n				
1	Courses of t	his	module									
	Course nr.		Course name			Workload (CP)			Teaching form			
	04-10-0395-	04-10-0395-vu Discontinuous Galerkin Methods				0		Lect	ure and	4		
	practice							tice				
2	Teaching co	nte	nt ntinuous Galerbii	n methods. Bound	edness S	Stahility (Onsistency Apr	novin	nation · Upw	inding		
	Limiting; IN	terio	r Penalty (IP), lo	ocal DG (LDG), as	o.; Implei	nentation	and practical e	xamp	les (e.g. in N	Intenne, Iatlab)		
3	Learning of	ject	ives	tract formulation	of discor	tinuous	Colorkin mother	le for	partial diffa	rontial		
	equations of	first	and second ord	er. They are able t	o explain	and anal	yse these metho	ods ar	id to apply the	hem to		
	convection dominated and time dependent problems.											
4	recommende	e for ed: r	equired: Introdu	ction to Numerical	l Analysis	or simila	r knowledge as	taugh	t in an engir	neering		
	programme;		T 1 A 1	· (D (1))((. 1 .	··· •			U	U		
5	Form of exa	min		as of Partial Differ	ential Eq	uations, r	functional Analy	/\$15				
	Module exar	n:										
	 Modul Fachprüfung 	e exa : (Te	am (Technical ex chnical Examina	kamination, Oral/v tion): Usually the	written ez exam is t	xaminatio aken in fo	on, Default RS) form of a writter	ı test.	except when	n there		
	are only a sr	nall	number of poter	ntial participants.	In this ca	ise, the ex	kam can be take	en in	the form of a	an oral		
	exam. The d lecture, base	ecisi ed or	ion about the for 1 the prospective	m of the exam is to number of studer	taken and its taking	l commur the exan	nicated during t	he firs	st two weeks	s of the		
6	Prerequisite	e for	the award of c	redit points	0							
	Passing the l	Fach	prüfung									
7	Grading Module exar	n:										
	• Modul	e ex	am (Technical ex	amination, Oral/v	written e	xaminatio	on, Weighting: 1	00 %)			
8	Usability of	the	module									
	B.Sc Mathen	natil	x, M.Sc. Mathem	atik, M.Sc. Mathe	matics							
9	References	ro /	Em. Mathan-	tion! Aspents of D:	antine		rin Motheda (D	olt C	nninger			
	B. Riviere: D	isco	ntinuous Galerki	in Methods for Sol	lving Ellip	otic and P	arabolic Equation	ons (E	Book, SIAM)			
10	Comment	1 -	r.1									
	recommende	ed: N	Mathematics: Ma	ster (num)								

Mo Geo	Module name Geometric Variational Problems												
Mo 04-	dule nr. 10-0511	Cr	edit points 9 CP	Workload 270 h	Self-stu	dy 180 h	Module durat	tion Module cycle Every 9, Semes		v cle emester			
Lan	iguage		, 01		Module	Module owner							
Ger	man/English	1.1.			Prof. Dr.	Prof. Dr. rer. nat. Karsten Große-Brauckmann							
1	Courses of t	this	Module			Worklos	ad (CP)	Теас	hing form				
	Course III.		Gourse name			WOLKIO		icac	ling form	HPW			
	04-10-0511-	vu	Geometric Vari	ational Problems		0		Lect prac	ure and tice	6			
2	2 Teaching content 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	 Learning objectives Students - are able to explain the relationship of variational functionals and their Euler equations beyond a concrete example - can derive existence and uniqueness statements as well as properties of the surface classes under consideration - know examples of research problems of the topic 												
4	Prerequisite recommende	e for ed: I	participation Differential geom	netry									
5	Form of exa Module exar • Modul Fachprüfung are only a sr exam. The d lecture, base	min n: e exa (Te nall ecisi ed or	ation am (Technical ex chnical Examina number of pote ion about the for 1 the prospective	kamination, Oral/ tion): Usually the ntial participants. rm of the exam is number of studer	written ex exam is t In this ca taken and nts taking	aminatio aken in fo se, the ex l commun the exam	n, Default RS) orm of a writter xam can be take hicated during t 1.	1 test, en in t he firs	except when the form of a st two weeks	n there an oral s of the			
6	Prerequisite Passing the I	e for Fach	the award of c prüfung	redit points									
7	Grading Module exar • Modul	n: e ex	am (Technical ez	kamination, Oral/	written ex	aminatio	n, Weighting: 1	.00 %))				
8	Usability of B.Sc Mathen	the natil	module <, M.Sc. Mathem	atik, M.Sc. Mathe	matics								
9	Referencesreferences provided in the lecture; examples include:Dierkes, Hildebrandt, Sauvigny: Minimal surfaces (Springer)Kenmotsu: Surfaces of constant mean curvature (AMS)												
10	Comment recommende	ed: N	Mathematics: Ma	ister (geo)									

Mo Mat	dule name thematical Mo	odell	ling of Fluid Inte	rfaces I						
Mo 04-	dule nr. 10-0291	Cr	edit points 5 CP	Workload 150 h	Self-stu	dy 105 h	Module durat	tion I	Module cy Every 9. Se	y cle emester
Lan Ger	guage man/English			I	Module Prof. Dr	owner rer. nat.	Dieter Bothe			
1	Courses of t	his	module		I					
	Course nr.		Course name			Workloa	ad (CP)	Teach	HPW	
	04-00-0286-	vu	Mathematical I ces	Modelling of Fluid	Interfa-	0		Lectur practio	e and e	3
2	2 Teaching content Basic calculus on surfaces; two-phase and surface transport theorems; remarks on quasilinear free boundary problems. Derivation of two-phase integral balance equations for mass, momentum and species mass; derivation of local balances and interfacial jump conditions; modeling of surface tension, mass transfer, evaporation, condensation. Continuum thermodynamics of fluid interface; entropy balance; entropy principle and second law; linear and non-linear closures.									
3	 3 Learning objectives Students learn to describe the phenomena occuring at fluid interfaces formulate the integral balances of two-phase fluid systems formulate the differential form of the balance equations formulate closure relations and transmission conditions describe dissipative processes in single-component two-phase fluid systems 									
4	Prerequisite recommende	e for ed: <i>A</i>	r participation Analysis, Ordinat	ry Differential Equ	ations. A	lternative	ly comparable p	orerequi	sites.	
5	Form of exa Module exar • Module Fachprüfung potential par form of the e number of st	min n: e exa : Us ticip xam tude	nation am (Technical e: ually the exam is pants. In this cas n is taken and cor ents taking the ex	xamination, Oral/ taken in form of a e, the exam can be nmunicated during xam.	written ex a written t e taken in g the first	xaminatio est, excep the form two week	on, Default RS) ot when there ar of an oral exam ss of the lecture,	e only a 1. The d based o	small nur ecision ab n the pros	nber of out the pective
6	Prerequisite Passing the I	e for Fach	the award of c prüfung	redit points						
7	Grading Module exar • Module	n: e ex	am (Technical e	xamination, Oral/	written ex	kaminatio	n, Weighting: 1	00 %)		
8	Usability of B.Sc Mathen	the natil	module k, M.Sc. Mathem	atik, M.Sc. Mathe	matics					
9	 9 References 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. 									lemann
10	Comment recommende	ed: N	Mathematics: Ma	aster (ana)						

Mo Mat	Module name Mathematical Modelling of Fluid Interfaces II												
Mo 04-	dule nr. 10-0309	Cre	edit points 5 CP	Workload 150 h	Self-stu	dy 105 h	Module durat	tion	n Module cycle Every 9. Semester				
Lan	iguage	I			Module	odule owner							
1		hie	module		PIOL DI	Tel. Ilat.	Dieter Botile						
1	Course nr.		Course name			Workloa	ad (CP)	Teac					
	04-10-0309-	vu	Mathematical I ces II	Modelling of Fluid	Interfa-	0		ure and tice	3				
2	Teaching co 1) Balance e balance 2) Mass tran 3) Thermody	equa sfer	nt tions for multip across fluidic in nically consisten	hase fluid system terfaces: chemical t modeling of dyn	s with in potential amic thre	erfacial 1 , interfac e phase c	mass; interface ial jump conditi ontact lines	mome	entum and	energy			
3	Learning objectives Students learn to - describe advanced phenomena at fluid interfaces with interfacial mass - formulate the transmission and thermodynamical jump conditions for description of transport and transfer process - describe the dissipative processes occuring at three phase contact lines												
4	Prerequisite recommende	e for ed: A	participation Analysis, Ordinat	ry Differential Equ	ations. M	athemati	cal Modeling of	fluid i	interfaces I				
5	Form of exa Module exar • Module Fachprüfung potential par form of the enumber of st	min n: e exa : Usu rticip exam tude	ation am (Technical ex ually the exam is pants. In this case is taken and cor nts taking the ex	kamination, Oral/v taken in form of a e, the exam can be nmunicated during tam.	written ex a written t e taken in g the first	aminatio est, excep the form two week	on, Duration: 60 ot when there ar of an oral exam ss of the lecture,	Min., e only n. The based	Default RS a small nur decision ab on the pros) nber of out the pective			
6	Prerequisite Passing the I	e for Fachj	the award of c prüfung	redit points									
7	Grading Module exar • Module	n: e exa	am (Technical ex	kamination, Oral/v	written ex	aminatio	n, Weighting: 1	.00 %)					
8	Usability of B.Sc Mathen	the natik	module c, M.Sc. Mathem	atik, M.Sc. Mathe	matics								
9	References I. Müller: Th J.C. Slattery, D.A. Edward 1991.	lerm L. S s, H.	odynamics, Pitm agis, ES. Oh: Iı . Brenner, D.T. W	aan 1985 hterfacial Transpo Jasan: Interfacial T	rt Phenon Fransport	nena (2no Processes	d ed.),Springer and Rheology,	2006. Butter	worth-Hein	emann			
10	Comment recommende	ed: N	Mathematics: Ma	ister (ana)									

Mo	dule name		on									
Mo 04-	dule nr. 11-0074	Cr	edit points 9 CP	Workload 270 h	Self-stu	dy 180 h	Module durat	tion	Module cycle		cle mester	
Lan Ger	guage man/English				Module owner Prof. Dr. rer. nat. Stefan Ulbrich							
1	Courses of	his	module									
	Course nr.		Course name			Workload (CP)			Teaching form HPW			
	04-00-0174-vu Nonlinear Optimization					0		Lect prac	ure ai tice	ıd	6	
2	Teaching content Modelling of practical applications as optimization problems; optimality conditions, duality theory; methods for unconstrained problems: Linesearchand Trust-Region-Methods; methods for constrained problems: penalty-, interior-point-, multiplier- and SQP-methods											
3	Learning objectives 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	Prerequisite for participation recommended: Introduction to Optimization											
5	Form of exa Module exar • Modul Fachprüfung are only a si exam. The d lecture, base	min n: e ex (Te nall ecis ed or	ation am (Technical ex chnical Examina number of poter ion about the for n the prospective	amination, Oral/ tion): Usually the ntial participants. m of the exam is number of studer	written ex exam is t In this ca taken and nts taking	xaminatio aken in fo use, the ex l commur the exam	n, Default RS) orm of a writter xam can be take hicated during t 1.	n test, en in 1 he firs	except w the form at two we	hen of a eks	there n oral of the	
6	Prerequisite Passing the I	e for Fach	the award of c prüfung	redit points								
7	Grading Module exan • Modul	n: e ex	am (Technical ex	amination, Oral/	written ex	kaminatio	n, Weighting: 1	.00 %))			
8	Usability of B.Sc Mather	the natil	module <, M.Sc. Mathem	atik, M.Sc. Mathe	matics							
9	References Geiger, Kanz Geiger, Kanz Nocedal, Wr	ow: ow: ight	Numerische Ver Theorie und Nu : Numerical Opti	fahren zur Lösung merik restringierte mization	g unrestri er Optimi	ngierter C erungsau	Optimierungsau fgaben	fgabei	1			
10	Comment	⊳d• №	Mathematics [.] Ma	ster (opt)								

Mo Nui	dule name nerical Metho	ods for Partial Differ	ential Equations									
Мо	dule nr.	Credit points	Workload	Self-stu	ıdy	Module durat	ion	Module cy	vcle			
04-	10-0391	9 CP	270 h		180 h	1 Term		Every 2. Se	emester			
Lar Ger	guage man/English			Prof. Dr. rer. nat. Jens Lang. Prof. Dr. rer. nat. Jan Giesselmann								
1	Courses of t	this module		11011 D1	. i cii iiuti							
	Course nr.	Course name			Workloa	ad (CP)	Теас	ching form	HPW			
	04-10-0391-	vu Numerical Met Equations	hods for Partial Dif	ferential	0		Lect prac	ure and tice	6			
2	Preaching 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 objectivesThe 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. Studentscan compare different methods and explain their advantages and limitations.											
4	Prerequisite recommende similar know	e for participation ed: Introduction to I vledge as taught in a	Numerical Analysis an engineering pro	s, Numeri gramme	cal Analy	sis of Ordinary	Differ	ential Equat	ions or			
5	Form of exa Module exar • Modul Fachprüfung are only a sr exam. The d lecture, base	mination m: e exam (Technical e g (Technical Examina mall number of pote lecision about the fo ed on the prospective	xamination, Oral/ ation): Usually the ential participants. rm of the exam is e number of studen	written e: exam is t In this ca taken and nts taking	xaminatio taken in fo ase, the ex l commur the exan	n, Default RS) orm of a writter xam can be take hicated during t 1.	n test, en in 1 he firs	except when the form of a st two weeks	n there an oral s of the			
6	Prerequisite Passing the I	e for the award of c Fachprüfung	credit points									
7	Grading Module exar • Modul	n: e exam (Technical e	xamination, Oral/	written e:	xaminatio	n, Weighting: 1	00 %)				
8	Usability of B.Sc Mathen	the module natik, M.Sc. Mathen	natik, M.Sc. Mathe	ematics								
9	References Braess: Finit Larsson, The Großmann, I	e Elemente: Theorie omee: Partial Differe Roos: Numerische B	e, schnelle Löser ur ential Equations wi ehandlung Partiell	nd Anwen th Numer er Differe	dungen in rical Meth ntialgleic	n der Elastizität ods, Springer, 2 hungen, Teubne	stheoi 2003. er, 200	rie, Springer)5.	; 2013.			
10	Comment recommende	ed: Mathematics: M	aster (num)									

Mo Nui	Module name Numerical Linear Algebra												
Mo	dule nr.	Cr	edit points	Workload	Self-stu	ıdy	Module durat	Nodule duration Module cy		vcle			
04-	11-0043/de		5 CP	150 h	105 h 1 Term Every 4. Semes								
Lan Ger	i guage man				Module owner Dr. rer. pat. Alf Gerisch								
1	Courses of	this	module										
	Course nr.		Course name		Workload (CP)			Теас	hing form				
	04 00 0120	3.71.1	Numorical Line	ar Algobra		0		Loct	uro and	HPW			
	04-00-0139-	vu	Numericai Line	ai Aigebia		0		prac	tice	5			
2	Teaching co	onte	nt	tivo motheda -:		un deserve	notition size		roblores				
2	Jearning of	ioct	r equations: itera	auve methods, sm	gular val		position, eigenv	arue p	orobiems.				
3	Learning objectives Students know about the most important numerical methods of linear algebra and they are able to explain, classify, and apply them.												
4	Prerequisite for participation recommended: Linear Algebra, Introduction to Numerical Analysis or similar knowledge												
5	Form of exa	min	ation										
	Module exar	n: e evi	am (Technical ex	xamination Oral/	written e	vaminatic	n Default RS)						
	Fachprüfung	g (Te	chnical Examina	tion): Usually the	exam is	taken in f	orm of a writter	ı test,	except when	n there			
	are only a si	nall ecisi	number of poter	ntial participants. m of the exam is:	In this ca taken and	ase, the ex	xam can be take	en in 1 he firs	the form of a	an oral s of the			
	lecture, base	ed or	n the prospective	number of studer	nts taking	the exan	neuteu uuring t 1.			, or the			
6	Prerequisite Passing the I	e for Fach	the award of c prüfung	redit points									
7	Grading												
	Module exar • Modul	n: e exa	am (Technical ex	kamination, Oral/	written e	xaminatic	on, Weighting: 1	00 %)				
8	Usability of B.Sc. Mathe	the mati	module k, M.Sc Mathem	atik, M.Sc. Mathe	matics								
9	References		л 1 т ·	Alashas OTANG									
	Demmel: Ap	au: 1 plie	d Numerical Linea	r Algebra, SIAM ear Algebra, SIAM									
	Stoer/Bulirs	ch: I	Numerische Mat	hematik 2, Spring	er								
10	Comment	∍d• N	Vathematics: Ba	chelor vear 3 (nur	n)								
	. ccommente			inclusion year o (nur)								

Mo Cor	dule name nputational F	luid	Dvnamics								
Mo 04-	dule nr. 10-0384	Cr	edit points 9 CP	Workload 270 h	Self-stu	dy 180 h	Module durat 1 Term	tion	Module c Every 9. S	ycle emester	
Lan Ger	guage man/English	1			Module Prof. Dr.	owner rer. nat.	Jan Giesselman	in			
1	Courses of	his	module		I						
	Course nr.		Course name			Workload (CP)		Teaching form		HPW	
	04-10-0384-	vu	Computational	Fluid Dynamics		0	Lecture and 6 practice				
2	 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 of The students know about methods. Th	oject s un the l ie str	tives derstand the bas pasics results on s udents are able t	ic equations of flu olvability of these o explain, analyse	id dynam models ar , and imp	ics, their nd about t lement tl	origin, and eler heir numerical s ne finite elemen	nentar solution at meth	y propertie n by finite o ods.	es. They element	
4	Prerequisite for participation recommended: required: basic knowledge of partial differential equations and numerical methods useful courses: Functional Analysis, Partial Differential Equations, Numerical Analysis of Elliptic/Parabolic Differential Equations										
5	Form of exa Module exar • Modul Fachprüfung are only a si exam. The d lecture, base	min n: e ex (Te nall ecis ed or	nation am (Technical ex- echnical Examina number of poten ion about the for n the prospective	kamination, Oral/ tion): Usually the ntial participants. rm of the exam is number of studer	written ex exam is t In this ca taken and nts taking	aminatio aken in fo ise, the ex l commur the exan	n, Default RS) orm of a writter xam can be take hicated during t 1.	n test, e en in tl he first	except whe he form of t two week	en there an oral s of the	
6	Prerequisite Passing the 1	e for Fach	the award of c prüfung	redit points							
7	Grading Module exan • Modul	n: e ex	am (Technical ex	amination, Oral/	written ex	aminatio	n, Weighting: 1	.00 %)			
8	Usability of B.Sc Mather	the natil	module k, M.Sc. Mathem	atik, M.Sc. Mathe	matics						
9	References D. Braess: Fi D. C. Brenne V. Girault, P. C. Johnson: R. Temam, N	nite er, L. -A. I Nun Navie	Elemente, Sprin R. Scott: The m Raviart: Finite El nerical solution c er-Stokes Equatio	ger. athematical theor ement Approxima of partial different ons, North-Hollan	y of finite ation of th ial equation d Publishi	element e Navier- ons by the ing.	methods, Sprin Stokes Equation e finite element	ger. 1s, Spr metho	inger. od, Dover.		
10	Comment										
recommended: Mathematics: Master (num)

Mo Pro	dule name bability Theo	ry											
Mo 04-	dule nr. 30-0045/en	Cr	edit points 9 CP	Workload 270 h	Self-stu	dy 180 h	Module durat	tion	Module cy Every 2. Se	v cle emester			
Lar Eng	iguage glish	1			Module Prof. Dr	Iodule owner rof. Dr. rer. nat. Volker Betz							
1	Courses of	this	module										
	Course nr.		Course name			Worklo	ad (CP)	Teac	hing form	HPW			
	04-00-0071-	vu	Probability The	eory		0		Lectu pract	ure and tice	6			
2	2 Teaching 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	Learning objectives 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	Prerequisite for participation recommended: Analysis, Integration Theory, Introduction to Stochastics												
5	 Form of examination Module exam: Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) 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	Prerequisite Passing the I	e fo r Fach	the award of c prüfung (techni	redit points cal examination)									
7	Grading Module exan • Modul	n: e ex	am (Technical e:	xamination, Oral/	written ex	kaminatio	n, Weighting: 1	.00 %))				
8	Usability of B.Sc. Mathe	the mati	module k, M.Sc Mathem	atik, M.Sc. Mathe	matics, L	aG Mathe	matik						
9	References Bauer: Probability Theory Billingsley: Probability and Measure Elstrodt: Maß-und Integrationstheorie Gänssler, Stute: Wahrscheinlichkeitstheorie Klenke: Wahrscheinlichkeitstheorie												
10	Comment recommende	ed: I	Mathematics: Ba	chelor year 3 (sto)), Teachir	lg Degree	S						

Mo Pro	dule name bability Theo	ry								
Mo	dule nr. 30-0045/de	Cr	edit points 9 CP	Workload 270 h	Self-stu	dy 180 h	Module durat	tion	Module cy Every 2, Se	cle emester
Lar Ger	iguage man	<u> </u>	,		Module Prof. Dr.	owner rer. nat.	Michael Kohler			
1	Courses of	his	module		I					
	Course nr.		Course name			Workloa	ad (CP)	Teac	hing form	HPW
	04-00-0141-	vu	Probability The	eory		0		Lectu pract	ire and ice	6
2	 Teaching 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	 3 Learning objectives 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	Prerequisite recommende	e fo r ed: /	participation Analysis, Integra	tion Theory, Introd	luction to	Stochast	ics			
5	Form of exa Module exar • Modul Fachprüfung are only a si exam. The d during the fi	min n: e ex g (te nall ecis rst t	ation am (Technical ex chnical examina number of pote ion about the for wo weeks of the	xamination, Oral/ tion): Usually the ntial participants. rm of the exam is lecture, based on	written ex exam is t In this ca taken and the prosp	caminatio aken in fo use, the ex l commun pective nu	n, Duration: 90 orm of a written kam can be take licated mber of studen) Min., 1 test, 6 en in ti ts taki	Default RS except when he form of a ng the exan) n there an oral n.
6	Prerequisite Passing the 1	e fo r Fach	the award of c prüfung (technie	redit points cal examination)						
7	Grading Module exan • Modul	n: e ex	am (Technical e	xamination, Oral/	written ex	kaminatio	n, Weighting: 1	.00 %)		
8	Usability of B.Sc. Mathe	the mati	module ik, M.Sc Mathem	atik, M.Sc. Mathe	matics, La	aG Mathe	matik			
9	References Bauer: Proba Billingsley: I Elstrodt: Ma Gänssler, Stu Klenke: Wah	abili Prob ß-ui ite: irsch	ty Theory ability and Meas nd Integrationsth Wahrscheinlichk leinlichkeitstheo	sure neorie eitstheorie rie					_	
10	Comment recommende	ed: 1	recommended: M	Iathematics: Bach	elor year	3 (sto), T	eaching Degree	es		

4 Elective Area C: Structural Mechanics and Dynamics

Mo Cor	dule name nposite Struct	tures	5									
Mo	dule nr.	Cr	edit points	Workload	Self-stu	Self-study Me		tion	Module cy	vcle		
Lar	nguage		4 CP	120 11	Module	owner	1 IeIIII		Every 2. Se	emester		
Eng	glish				Prof. Dr	Prof. DrIng. Christian Mittelstedt						
1	Courses of	this	module			T1 1 1	1 (02)	-	1			
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW		
	16-12-3174-	vl	Composite Stru	ictures		0		Lect	Lecture 2			
	16-12-3174-	ue	Composite Stru	ictures		0		Prac	ctice	0		
	Historical developments, Nomenclature, Fibers and matrices, Semi-finished products, Behaviour of a laminate layer, Classical Laminate Plate Theory, Influence of moisture and temperature, Fracture and degradation, Joints (circumferential joints, bolted joints, bonded joints), Optimization of laminates, Design guidelines, Stress concentration problems, Stability problems, Examples from aircraft engineering, Example: Predesign of a thin-walled composite beam											
3	 Learning objectives Upon successful completion of this module, students should be able to: 1. Select fibers, matrices and semi-finished products according to a specific task. 2. Perform basic static analyses of thin-walled composite structures. 3. Apply classical laminated plate theory for basic composite laminate problems and to perform strength assessments under consideration of static loads as well as moisture and temperature loads. 4. Understand the most relevant stability and stress concentration problems in the framework of composite structures and to perform according analyses. 5. Understand and apply construction principles in composites engineering. 											
4	Prerequisite Attending an II" is recomm	e for nd su nend	participation accesfully compleded.	eting the modules	"Lightwe	ight Engiı	neering I" and "	Light	weight Engir	neering		
5	Form of exa Module exar Modul Course relat [16-12 Oral exam 3 minutes ora	min n: e ex ed e 2-31 30 m l exa	aation am (Technical ex xam: 74-ue] (Technica iin., divided into umination (2/3)a	kamination, Oral e ll examination, Re o 10 minutes prese and report (design	examinati port, p/n entation o project, j	on, Durat p RS) of the res pnp).	ion: 30 Min., D ults of the desi	efault gn pr	t RS) oject (1/3) a	and 20		
6	Prerequisite Passing the	e for exan	the award of c ninations.	redit points								
7	Grading Module exan • Modul Course relat • [16-12	m: e ex ed e 2-31	am (Technical ex xam: 74-ue] (Technica	αamination, Oral ε l examination, Re	examinati port, Wei	on, Weigł ghting: 0	nting: 100 %) %)					
8	Usability of	the	module									

	WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau) Master AE II Kernlehrveranstaltung Master MB II SP SUR WPB Master PST IV (Kernlehrveranstaltungen der Papiertechnik) Angewandte Mechanik Mechatronik
9	References ALTENBACH, H., ALTENBACH, J. und RIKARDS, R., 1996. Einführung in die Mechanik der Laminat- und Sandwichtragwerke. Stuttgart: Deutscher Verlag der Grundstoffindustrie. JONES, R.M., 1975. Mechanics of composite materials. Washington, USA: Scripta Book Co. MITTELSTEDT, C. und BECKER, W., 2016. Strukturmechanik ebener Laminate. Darmstadt: Studienbereich Mechanik, TU Darmstadt. SCHÜRMANN, H., 2005. Konstruieren mit Faser-Kunststoff-Verbunden. Berlin et al.: Springer.
10	Comment

Mo Ene	dule name ergy Methods	in St	ructural Mechar	nics								
Mo 16-	dule nr. 12-3134	Cre	edit points 4 CP	Workload 120 h	Self-stu	i dy 75 h	Module durat	tion	Module cy Every 2. Se	v cle emester		
Lan Eng	iguage Ilish	<u> </u>		I	Module Prof. Dr	ule owner DrIng. Christian Mittelstedt						
1	Courses of t	this	module		1							
	Course nr.		Course name			Workloa	ad (CP)	Теа	ching form	HPW		
	16-12-3134- 16-12-3134-	vl ue	Energy Method Energy Method	ls in Structural Me ls in Structural Me	echanics echanics	0		Lect Prac	ure tice	2		
2	Teaching co Work and er theorems; Ca	onter nergy astigi	nt 7; Virtual work; I liano's theorems	Principle of virtua ; Reciprocity theor	l displace ems; App	ments; Pr roximate	inciple of virtua methods: Galer	al forc kin, R	es; Unity itz, finite ele	ements.		
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Explain the basic energy methods of structural mechanics and to apply them to simple applications. 2. Choose an adequate method for a given specific lightweight engineering application case and to use it independently. 3. Develop practically relevant approximate methods for static problems, based on the basic principles and methods (e.g. principles of virtual displacements, virtual forces, Ritz method). 4. Develop fast and simple approximate solutions for practical lightweight engineering problems, based on the basic underlying principles. 											
4	Prerequisite	e for	participation									
5	Form of exa Module exar • Modul Oral examin	min n: e exa atior	ation am (Technical ex n (30 min)	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	RS)			
6	Prerequisite Passing the e	e for exan	the award of c nination.	redit points								
7	Grading Module exar • Modul	n: e exa	am (Technical ex	xamination, Oral e	examinati	on, Weigł	nting: 100 %)					
8	8 Usability of the module WPB Master MPE III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Angewandte Mechanik Mechatronik											
9	 References Mittelstedt, C., 2021. Rechenmethoden des Leichtbaus. Berlin: Springer Vieweg. Mittelstedt, C., 2021. Structural Mechanics in Lightweight Engineering. Cham (Switzerland): Springer Nature. 											
10	Comment											

Mo Fur	dule name	Mac	chine Acoustics								
Mo 16-2	dule nr. 26-5070	Cr	edit points 6 CP	Workload 180 h	Self-stu	l dy 135 h	Module durat 1 Term	tion	Module cy Winter terr	r cle m	
Lan Ger	i guage man				Module owner Prof. DrIng. Tobias Melz						
1	Courses of	this	module								
	Course nr.		Course name			Workload (CP)		Теа	ching form	HPW	
	16-26-5070-	vl	Fundamentals	of Machine Acous	tics	0		Lect	ure	3	
2	2 Teaching content The module includes the explanation and application of fundamental terms in technical acoustics (e.g., frequency, sound pressure, sound power, sound intensity, particle velocity, specific acoustic impedance, levels), level arithmetic, frequency analysis, acoustic filter and weighting functions, fundamental equation of machine acoustics, mirror sound sources and interference, various types of acoustic radiators, various sound power measurement methods										
3	 3 Learning objectives On successful completion of this module, students should be able to: Know the various physical quantities relevant for (technical) acoustics, explain the differences between them, and derive or combine such quantities from/with each other. Calculate levels of various physical/acoustic quantities and perform various level calculations such as the total or average level of several sound sources. Explain the fundamentals of Fourier/frequency analysis and recognize the advantages and drawbacks of various ways to present results of frequency analyses. Distinguish various acoustic filter functions and calculate octave band and one-third octave band spectra from given narrowband spectra. Apply acoustic weighting functions (such as A-, C- or Z-weighting) in a meaningful manner and explain the reasons for implementing such weighting curves. Explain the physical sound generation mechanisms of dynamically excited machine structures. Recognize the chain of sound generation from the dynamic excitation up to the sound radiation based on the fundamental equation of machine acoustics. Recognize the influence and the effects of mirror sound sources and consider these when analyzing acoustic measurements. 										
4	Prerequisite no specific l mechanics, j	e for know phys	participation vledge is require ics, and machine	ed except a recom	imendatio	on of basi	ic understandin	ıg in 1	machine dyr	ıamics,	
5	Form of exa Module exa • Modul Written exa	min n: e ex: n 2 l	aation am (Technical ex h	xamination, Exam	ination, D	Ouration:	120 Min., Defat	ult RS)		
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points							
7	Grading Module exan • Modul	n: e exa	am (Technical ex	amination, Exam	ination, V	Veighting	: 100 %)				
8	Usability of	the	module					_			

	WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)
	Master MB II SP FAS
	WPB Master PST III (Wahlfächer aus Natur- und Ingenieurwissenschaft)
9	References
	comprehensive class notes (two volumes, approx. 1100 pages for "Machine Acoustics - Fundamentals 1+2")
	available for purchase
	additional recommended text books:
	Kollmann, F.G.: "Maschinenakustik", 2. Auflage, Springer-Verlag, 2000
	Kollmann, F.G., Schösser, T.F., Angert, R.: "Praktische Maschinenakustik", Springer-Verlag, 2006
	Henn, H., Sinambari, G.R., Fallen, M.: "Ingenieurakustik", 4. Auflage, Vieweg+Teubner Verlag, 2008
	Schirmer, W. (Hrsg.): "Technischer Lärmschutz", 2. Auflage, Springer-Verlag, 2006
	Möser, M.: "Technische Akustik", 9. Auflage, Springer-Verlag, 2012
	Müller, G., Möser, M. (Hrsg.): "Taschenbuch der Technischen Akustik", 3. Auflage, Springer-Verlag, 2004
	Möser, M. (Hrsg.): "Messtechnik der Akustik", Springer-Verlag, 2010
	Bies, D.A., Hansen, C.H.: "Engineering Noise Control: Theory and Practice", 4. Auflage, 2009
	Vér, I.L., Beranek, L. L.: "Noise and Vibration Control Engineering", 2. Auflage, John Wiley & Sons, 2005
	Rossing, T.D. (Hrsg.): "Springer Handbook of Acoustics", Springer-Verlag, 2007.
10	Comment

Mo Ligl	dule name ntweight Enginee	ering I									
Mo 16-	dule nr. C 1 12-5040	redit points 4 CP	Workload 120 h	Self-stu	i dy 75 h	Module dura 1 Term	tion	Module cy Summer te	v cle erm		
Lan Eng	guage lish			Module owner Prof. DrIng. Christian Mittelstedt							
1	Courses of this	module									
	Course nr.	Course name			Worklo	ad (CP)	Teac	ching form	нрш		
	16-12-5040-vl	Lightweight En	gineering I		0		Lect	ure	2		
	16-12-5040-ue	Lightweight En	gineering I		0		Prac	tice	1		
2	 Teaching content The contents of this course will be illustrated by assessment of the following representative parts of a passenger aircraft that will be discussed in detail: 1) fuselage frame, 2) skin panel (system consisting of skin, stringer, frame), 3) cross-beam, 4) rear pressure bulkhead. Contents: 										
3	Learning object On successful co 1. Choose adequ 2. Transfer the so 3. Select and size	tives ompletion of this uate methods to c specific lightweig ze the most suitab	module, students lesign a structure ht engineering me ole geometries for	should be as light a echanics t lightweig	e able to: s possible o arbitrar ght constr	y practically rel uctions.	levant	problems			
4	Prerequisite fo	r participation									
5	Form of examin Module exam: • Module ex	nation xam (Technical ex	xamination, Oral e	examinati	on, Durat	ion: 20 Min., D	efault	RS)			
6	Prerequisite fo Passing the example the example of the example o	r the award of c mination.	redit points								

7	GradingModule exam:Module exam (Technical examination, Oral examination, Weighting: 100 %)
8	Usability of the module WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau) Master AE II Kernlehrveranstaltung Master MB II SP SUR WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Master Mechanik / Master Mechatronik
9 10	ReferencesGROSS, D., HAUGER, W. und WRIGGERS, P., 2011. Technische Mechanik 4. 8. Auflage. Berlin et al.: Springer.WIEDEMANN, J., 1996. Leichtbau 1: Elemente. 2. Auflage. Berlin et al.: Springer Verlag.Comment

Mo Lig	dule name	nee	ring II									
Mo 16-	dule nr. 12-5050	Cr	edit points 4 CP	Workload 120 h	Self-stu	i dy 75 h	Module durat	tion	Module cy Summer te	v cle erm		
Lan Eng	guage lish				Module owner Prof. DrIng. Christian Mittelstedt							
1	Courses of t	this	module									
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW		
	16-12-5050-	vl	Lightweight En	gineering II		0		Lect	ure	2		
	16-12-5050-	ue	Lightweight En	gineering II		0		Prac	tice	1		
2	 Teaching content The contents of this course will be illustrated using the same representative parts as they were already discussed in the course "lightweight engineering I". In detail, the contents are: Load bearing structures I: Shear wall girders (open / closed; statically determinate / indeterminate), example system stringer / frame / skin. Load bearing structures II: Isotropic and orthotropic disks, disk equations and solutions, example: panels with circular openings, orthotropic aircraft frame. Load bearing structures III: Orthotropic plates, plate equations and solutions, example: floor plate A350 (sandwich). Buckling I: Buckling of plates: exact solution methods, example: skin panel. Buckling II: Buckling of stiffened plates, exact solution methods, approximation methods, impact of stiffeners lightweight justification. Buckling III: Local buckling of thin-walled beams, examples: Z-frame, omega-frame. Composite Structures II: Construction to Classical Laminated Plate Theory, Example: skin panel A350. Composite Structures II: Introduction to Classical Laminated Plate Theory, Example: skin panel A350. Sandwich structures II: Introduction, advantages and disadvantages, core materials, manufacturing methods applications, load introductions. Sandwich structures II: Shear deformation theories. strength assessment, lightweight justification, example 								ethods, ample :			
3	Learning of On successfu 1. Assess the exact solution 2. Solve stat 3. Select app 4. Design loa	oject 11 co 2 gen on m ic bo orop ad bo	tives ompletion of this neral characteris ethods to practic oundary value pr riate solution me earing lightweig	module, students tics of the static l cally relevant exar oblems of load be ethods for specific ht structures in a	should be behaviour nples. aring stru practical safe mann	e able to: of lightw actures us problems her and to	veight structure ing approximat and to apply th o find optimal d	es and e solu nem ir esigns	to apply av tion method ndependently	ailable ls. y.		
4	Prerequisite Lightweight	e for eng	participation ineering I recom	mended.								
5	Form of exa Module exa • Modul Oral exam (2	min n: e ex 20 n	aation am (Technical ex nin.)	xamination, Oral 6	examinati	on, Durat	ion: 20 Min., D	efault	RS)			
6	Prerequisite Passing the e	e for	the award of c nination.	redit points								
7	Grading Module exan • Modul	n: e ex	am (Technical ex	amination, Oral e	examinati	on, Weigł	nting: 100 %)					

8	Usability of the module
	WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)
	Master AE II Kernlehrveranstaltung
	Master MB II SP SUR
	WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
	Master Mechanik
	Master Mechatronik
9	References
	ALTENBACH, H., ALTENBACH, J. und NAUMENKO, K., 1998. Ebene Flächentragwerke. Berlin et al.: Springer.
	GROSS, D., HAUGER, W. und WRIGGERS, P., 2011. Technische Mechanik 4. 8. Auflage. Berlin et al.: Springer.
	WIEDEMANN, J., 1996. Leichtbau 1: Elemente. 2. Auflage. Berlin et al.: Springer Verlag.
10	Comment

Mo The	dule name eory of Shells									
Mo 16-	dule nr. 12-3194	Cr	edit points 4 CP	Workload 120 h	Self-stu	. dy 90 h	Module dura 1 Term	tion	Module cy Every 2. Se	/ cle emester
Lan Ger	iguage man	1		1	Module Prof. Dr	owner Ing. Chr	istian Mittelste	dt		
1	Courses of	this	module		1					
	Course nr.		Course name			Workloa	ad (CP)	Теа	ching form	HPW
	16-12-3194-	vl	Theory of shell	S		0		Lect	ure	2
2	2 Teaching content Curved beams as introductory motivation (determination of stress resultants; pressure line determination; deformations); types of shells; shell loads; assumptions of technical shell theory; state variables; membrane theory: assumptions, basic equations, shells of revolutions, selected solutions, kinematics and deformations; bending theory of shells of revolution: basic equations, special cases, vessel theory; the force method: boundary layer phenomena, statically indeterminate shells; energy methods; finite elements for shells: shells of revolution, arbitrary shells; layered shells; higher-order shell theories; introduction to shell buckling; stiffened shells									
3	 Learning objectives On successful completion of this module, students should be able to: Perform analyses for elementary shell structures autonomously. Explain the special load bearing characteristics of shells and to use those for the dimensioning of shell structures. Explain the stability behaviour of shells and to perform according buckling analyses. 									
4	Prerequisite	e foi	participation							
5	Form of exa Module exan • Modul Oral exam (2	n mir n: e ex 20 n	a tion am (Technical e: nin.)	xamination, Oral e	examinati	on, Durat	ion: 20 Min., D	efault	t RS)	
6	Prerequisite Passing the	e fo i exan	the award of c nination.	redit points						
7	Grading Module exa • Modul	n: e ex	am (Technical e:	xamination, Oral e	examinati	on, Weigł	nting: 100 %)			
8	 Usability of the module WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Angewandte Mechanik Mechatronik 									
9	References FLÜGGE, W. WIEDEMAN BRUSH, D.O	, 19 N, J. . / A	62. Statik und D ., 1996. Leichtba ALMROTH, B.O.,	ynamik der Schale u 1: Elemente. 2. 1975. Buckling of	en. 3. Auf Auflage. I bars, pla	lage. Berl Berlin et a tes and sl	in et al.: Spring ıl.: Springer Ver ıells. New York	ger. rlag. et al.	: McGraw-H	ill.
10	Comment									

Mo The	dule name corv of Elastic	Stal	oility							
Mo 16-	dule nr. 12-3144	Cr	edit points 4 CP	Workload 120 h	Self-stu	l dy 75 h	Module durat	tion	Module cy Every 2. Se	z cle emester
Lar Eng	iguage lish	1		I	Module Prof. Dr	owner Ing. Chr	ristian Mittelstee	dt		
1	Courses of t	this	module							
	Course nr.		Course name			Worklo	ad (CP)	Теа	ching form	HPW
	16-12-3144-	vl	Theory of Elast	ic Stability		0		Lect	ure	2
	16-12-3144-	ue	Theory of Elast	ic Stability		0		Prac	tice	1
2	Teaching co Typical stabi Buckling of J	onte ility plate	nt problems in elas es and shells.	tostatics; Buckling	of beams	s; Flexura	l torsional buck	ling a	nd lateral bu	ıckling;
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Differentiate and explain typical stability problems and use the according solution methods for application cases as they are relevant in lightweight engineering. 2. Solve stability problems of beam structures in an exact and approximate way. 3. Solve stability problems of plates in an exact and approximate way. 4. Choose and apply solution methods for given specific practical problems independently. 5. Develop approximate solutions for practically relevant stability problems. 6. Design lightweight structures concerning their stability behavior in a secure way. 									
4	Prerequisite	e for	participation							
5	Form of exa Module exar • Modul Oral exam 3	n: n: e ex: 0 mi	a tion am (Technical ex in	xamination, Oral 6	examinati	on, Durat	tion: 30 Min., D	efault	RS)	
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points						
7	Grading Module exar • Modul	n: e ex	am (Technical ex	amination, Oral e	examinati	on, Weigl	nting: 100 %)			
8	Usability of WPB Master II (Kernlehrv WPB Master Angewandte Mechatronik	the MPI veran PST Me	module E III (Wahlfächer nstaltungen aus C III (Fächer aus chanik	aus Natur- und In dem Maschinenba Natur- und Ingeni	genieurw uu)] eurwisser	issenscha nschaft fü	ft) [Im WiSe 20 ir Papiertechnik	16/17)	7: WPB Maste	er MPE
9	ReferencesALFUTOV, N.A., 1999. Stability of elastic structures. Berlin et al.: Springer Verlag.CHEN, W.F. und LUI, E.M., 1987. Structural stability. New York et al.: Elsevier.PETERSEN, C., 1982. Statik und Stabilität der Baukonstruktionen. 2. Auflage. Braunschweig / Wiesbaden:Vieweg Verlag.PFLÜGER, A., 1975. Stabilitätsprobleme der Elastostatik. Berlin et al.: Springer Verlag.WIEDEMANN, J., 1996. Leichtbau 1: Elemente. 2. Auflage. Berlin et al.: Springer Verlag.Comment									

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5 Elective Area C: Experimental Mechanics

Mo Me	Iodule name Iethods of experimental mechanics										
Mo	dule nr.	Cr	edit points	Workload	Self-stu	120 h	Module durat	tion	Module cy	v cle	
Lar	iguage		0.01	100 11	Module	owner	1 ICIIII		Every 2. Se		
Ger	man										
1	Courses of t	his	module				1 (27)	_			
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW	
	13-I2-0015-ı	ıe	Experimentelle Übung	Methoden der Me	chanik -	0		Prac	tice	2	
	13-I2-0014-t	t	Experimentelle	Methoden der Me	echanik	0		Tuto	orial	2	
2	Teaching co Tensile tests strain gauge	nte , inc s	nt remental step te	sts, digital image	correlatio	on, resona	nce test machin	ies,			
3	 After the lecture students are able to: Design and perform experimental, mechanical testing Explain and describe experimental setups Identify possible sources of errors for experimental testing Interpret, understand and evaluate experimental results and write test reports Compare experimental with calculation results and interpret the discrepancies Work together in teams, be a part of ethically correct discussions with opposite positions Present the results in a suitable manner 										
4	Prerequisite	e for	participation								
5	Form of exa Module exar • Modul Technical Ex As a rule, th participants.	min n: e exa ami e exa	a tion am (Technical ex nation: Oral Exa amination takes	kamination, Oral/ mination (20 min the form of an ora	written e: .) / Writt al examin	xaminatio en Examin ation, or	n, Duration: 90 nation (90 min. a written exami)) inatio	, Default RS) e more	
6	Prerequisite Passing the 1	e for nod	• the award of c ule examination	redit points (s)							
7	Grading Module exar • Modul	n: e ex	am (Technical ez	kamination, Oral/v	written e	xaminatio	n, Weighting: 1	.00 %)		
8	Usability of	the	module								
9	References										
10	Comment										

Mo Mea	Module name Measuring Techniques in Fluid Mechanics										
Mo	dule nr.	Credit points	Workload	Self-stu	dy	Module durat	ion	Module cy	vcle		
16-	11-5160	4 CP	120 h		90 h	1 Term		Every 2. Se	emester		
Lan Ger	guage man			Module Prof. Dr	e owner Ing. Jean	nette Hussong					
1	Courses of t	his module									
	Course nr.	Course name		Workload (CP)			Tea	ching form	HPW		
	16-11-5160-	vl Measuring Tech	niques in Fluid Me	echanics	0		Lect	ure	2		
2	2 Teaching content The role of experiments in fluid mechanics, interplay among experiment, theory, and simulations, model scaling and design of experiments, statistical description of turbulence flows and their measurement, signal and data processing, analysis of measurement data, including uncertainty analysis. Various measurement techniques: pressure measurements, visualization, thermal anemometry, laser Doppler technique, phase Doppler, particle image velocimetry										
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Describe the measurement principles of the most common measurement techniques in fluid mechanics. 2. Select the most appropriate measurement technique for a given measurement task. 3. Describe challenges of performing measurements in turbulent flows and in wall proximity. 4. Analyse test data and select and apply various techniques of data analysis. 										
4	Prerequisite	e for participation									
5	Form of exa Module exar • Module Oral exam 3	mination n: e exam (Technical ex 0 min.	amination, Oral e	examinati	on, Durat	ion: 30 Min., De	efault	RS)			
6	Prerequisite Passing the e	e for the award of c	redit points								
7	Grading Module exar • Module	n: e exam (Technical ex	xamination, Oral e	examinati	on, Weigł	nting: 100 %)					
8	Usability of WPB Master WPB Master	the module MPE III (Fächer aus PST III (Fächer aus	Natur- und Ingen Natur- und Ingeni	ieurwisse eurwisse	enschaft fü nschaft fü	ir Papiertechnik r Papiertechnik	(x) ()				
9	References Slides and fu	urther material are a	vailable via the M	oodle sys	tem						
10	0 Comment										

Mo Ana	dule name	meri	imental Methods	s of Structural Dyn	amics					
Mo 16-1	dule nr. 25-3194	Cr	edit points 6 CP	Workload 180 h	Self-stu	1 dy 120 h	Module durat 1 Term	tion	Module cy Every 2. Se	v cle emester
Lar Ger	i guage man	1		1	Module Dr. Ing.	e owner Benjamir	n Siegl			
1	Courses of t	this	module							
	Course nr.		Course name			Workloa	ad (CP)	Теас	ching form	HPW
	16-25-3194-	vl	Analytical and structural dyna	experimental met	thods of	0		Lect	ure	3
	16-25-3194-	ue	Analytical and structural dyna	experimental met	thods of	0		Prac	tice	1
2	Building up a feasible measuring chain to detect vibrations; Functionality of devices e.g. (measuring) ampli- fiers, analog filters (and their digital usage in computers), integrators, differentiators; Signal analysis in time, frequency and amplitude domain; System Identification: different estimator functions for transfer functions, in- dicator functions for mode detection, experimental modal analysis; Structural Modification of already identified structures; Substructure Techniques e.g. modal reduction.									
3	 3 Learning objectives On successful completion of this module, students should be able to: Choose suitable sensors for dynamic measuring of mechanical quantities to construct a reasonable measuring chain with the chosen sensors Analyze and interpret the measured signals accordingly to the measuring goal and quantify the occurring measurement errors Manipulate the measured signals (where appropriate using MATLAB) in a manner that the quality regarding the measuring goal is increased (postprocessing) Identify the modal parameters of the dynamic system unambiguously by performing an experimental modal analysis Quantify subsequent changes on the-already identified-vibration system relating to the unmodified dynamic 									
4	Prerequisite Advanced M	e for Iachi	participation ne Dynamics/St	ructural Dynamics	s recomm	ended.				
5	Form of exa Module exar • Modul Written (60 circumstance	min n: e exa min es (r	ation am (Technical ex) or oral exam (number of studer	xamination, Oral/v 30 min). Will be a nts etc.).	written e: announce	xaminatio d at the b	on, Default RS) beginning of the	e term	depending	on the
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points						
7	Grading Module exar • Modul	n: e ex	am (Technical e	kamination, Oral/v	written e	xaminatio	on, Weighting: 1	.00 %))	
8	Usability of WPB Master WPB Master (WI/MB, Me	the MB PST echat	module III (Wahlfächer III (Fächer aus tronik, ETIT)	aus Natur- und In Natur- und Ingeni	genieurw eurwisse	vissenscha nschaft fü	nft) ar Papiertechnik)		
9	References									

	Markert, R.: Schwingungsmesstechnik. Skript zur Vorlesung.
10	Comment

6 Elective Area C: Environmental and Bio-Mechanics

Mo	Module name Biomachanik										
Mo 03-	dule nr. 05-0057	Credit points 6 CP	Workload 180 h	Self-stu	dy 120 h	Module durat 1 Term	ion	Module cy Every 2. Se	v cle emester		
Lar Ger	iguage man	I	1	Module Prof. Dr.	e owner . phil. An	dré Seyfarth					
1	Courses of	this module			-						
	Course nr.	Course name			Worklo	ad (CP)	Теа	ching form	HPW		
	03-46-0007-	vl Einführung in	die Biomechanik		0		Lect	ure	2		
	03-46-0008-	ps Biomechanik			0		Intro min	oductory se-	2		
2	Teaching co	ontent							1		
3	Learning of	ojectives									
4	Prerequisite for participation										
5	 Form of examination Module exam: Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) Course related exam: [03-46-0008-ps] (Study achievement, Oral/written examination, Default RS) 										
6	Prerequisite Passing the	e for the award of c final module examin	r edit points ation								
7	Grading Module exan • Modul Course relat • [03-46	m: e exam (Technical e ed exam: 5-0008-ps] (Study ac	xamination, Exam hievement, Oral/v	ination, V written ex	Veighting aminatio	: 1) n, Weighting: 1))				
8	Usability of the module										
9	References										
10	Comment										

Mo Rive	Module name River Dynamics										
Mo	dule nr.	Cr	edit points 3 CP	Workload 90 h	Self-stu	1 dy 60 h	Module durat	Ation Module cycle Every 2. Semester		/ cle emester	
Lan Ger	nguage man	<u> </u>			Module Prof. Dr	e owner Ing. Bor	is Lehmann				
1	Courses of	this	module		1						
	Course nr.		Course name			Workloa	ad (CP)	Теа	ching form	HPW	
	13-L2-0003-	vl	River Dynamic	S		0		Lect	ure	2	
2	Teaching content - definition of water course morphology - space-time models - bed-load transport - suspended load transport - interaction										
3	Learning objectives By successfully passing the module examination, students can - outline phenomenon's of fluvial morphology, - estimate sediment transport rates, - define suspended load transport, - work out advanced demanding solutions.										
4	Prerequisite "Grundlager 13-L2-M002	e for 1 de1 / 13	r participation r Rohr- und Geri I-L2-M003/3)	nnehydraulik" (13	-L2-M00	9), Modul	e "Wasserbau I,	II, III	[" (13-L2-M0)01/3 /	
5	Form of exa Module exa • Modul	min n: e ex	nation am (Technical ex	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	t RS)		
6	Prerequisite Passing the p	e for mod	the award of c ule examination	redit points (s)							
7	Grading Module exan • Modul	n: e ex	am (Technical ex	xamination, Oral e	examinati	on, Weigł	nting: 1)				
8	Usability of	the	module								
9	References										
10	Comment										

Mo Nui	Iodule name Jumerical Simulations in Geotechnical Engineering									
Mo 13-	dule nr. C0-M041	Cr	edit points 3 CP	Workload 90 h	Self-studyModule dur60 h1 Term			tion	ion Module cycle Every 2. Semester	
Lan Eng	guage lish				Module Prof. Dr	e owner Ing. Hau	ıke Zachert			
1	Courses of t	his	module							
	Course nr.		Course name			Workload (CP)			ching form	HPW
	13-C0-0041-	vl	Numerical Sim	ulations in Geote	echnical	0		Lect	ure	1
	13-C0-0041-	ue	Numerical Sim Engineering - F	ulations in Geote Exercise	echnical	0		Prac	tice	1
2	Teaching co	onte	nt			L				1
3	Learning objectives									
4	Prerequisite for participation									
5	Form of exa Module exar • Modul • Modul	min n: e ex e ex	a tion am (Study achie am (Technical ex	vement, Homewor xamination, Oral e	k, works xaminati	heet, p/nj on, Durat	p RS) ion: 30 Min., D	efault	RS)	
6	Prerequisite Passing the 1	e for nod	the award of c ule examination	redit points (s)						
7	Grading Module exar • Modul • Modul	n: e ex e ex	am (Study achie am (Technical ex	vement, Homewor kamination, Oral e	·k, works xaminati	heet, Weig on, Weigł	ghting: 0 %) nting: 100 %)			
8	Usability of	the	module							
9	References									
10	Comment									

Mo Nur	Module name Numerical modeling in Hydraulic Engineering											
Mo	dule nr.	Cr	edit points	Workload	Self-stu	ldy	Module durat	ion	Module cy	vcle		
13-1 Lor	L2-M006		3 CP	90 h	Madula	60 h	1 Term		Every 2. Se	emester		
Ger	man				Prof. Dr	Prof. DrIng. Boris Lehmann						
1	Courses of	his	module		I	0						
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW		
	13-L2-0007-	vl	Numerical Moo neering	delling in Hydrau	lic Engi-	0		Lect	ure	2		
2	Teaching content - Definition of the model term, model types in hydraulic engineering - Applications of numerical models for hydraulic engineering - Mathematical principles: mass, momentum, energy - Navier-Stokes equations and simplified forms - Analytical solution possibilities - Numerical solution possibilities - Turbulence consideration in numerical solution methods - Working steps in modelling and model application - Examples of use											
3	Learning objectives The students can select a suitable numerical model approach for given hydraulic engineering problems and to carry out the necessary steps for model creation and application. The strengths, weaknesses and application limits of hydraulic engineering numerical models are known and an overview of software solutions currently used in practice is available.											
4	Prerequisite Recommend wasserschutz	e fo r ed: z un	participation "Grundlagen der d Wasserkraftnu	Rohr- und Gerinr tzung (13-L2-M00	nehydraul 1/3) and	ik" (13-L2 Wasserba	2-M021), "Wasso au II, III" (13-L2	erbau 2-M00	II: Flussbau 2/ 13-L2-M	, Hoch- 003/3)		
5	Form of exa Module exa • Modul	min n: e ex	am (Technical ex	xamination, Oral e	examinati	on, Durat	ion: 30 Min., D	efault	RS)			
6	Prerequisite Passing the p	e fo r nod	the award of c ule examination	redit points (s)								
7	Grading Module exan • Modul	n: e ex	am (Technical ex	αamination, Oral ε	examinati	on, Weigł	nting: 1)					
8	Usability of	the	module									
9	References Slide handor	uts a	and references to	supplementary te	echnical li	iterature a	are distributed o	during	g the course.			
10	Comment											

Mo	Module name Biomaterials and Tissue Engineering										
Mo	dule nr. 17-3294	Cro	edit points 4 CP	Workload	Self-stu	dy 90 h	Module durat	ion	Module cy	v cle	
Lan	iguage		1 01	120 11	Module	owner	1 101111				
Eng	lish	hia	madula		Prof. Dr	-Ing. And	reas Blaeser				
1	Courses of t		Course name			Workloa	ad (CP)	Теас	ching form		
		_		1						HPW	
2	16-17-3294-	vl	Biomaterials ar	nd Tissue Engineer	ring	0		Lect	ure	2	
	Biological fundamentals: anatomy of eukaryotic cells; cell culture fundamentals; interaction of cells and biomaterials in 2 and 3D; biomaterials and hydrogels for tissue culture; classification; composition and selection of biomaterials for culture of soft and hard tissue; characterization methods of biomaterials and hydrogels (rheological, mechanical and biological characterization); tissue culture in bioreactors; static and dynamic cell culture in culture dishes and various bioreactors; mechanobiological aspects of tissue culture.										
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Explain and classify biological fundamentals and applications of biomaterials. 2. Select biomaterials for the cultivation of soft and hard tissue and apply them in a use case. 3. Compare and contrast biomaterials in terms of their biomedical applicability. 4. Assess the interaction of cells and biomaterials in 2 and 3D. 5. Choose and apply suitable characterization methods for biomaterials and hydrogels according to appropriate criteria. 6. Evaluate different types of tissue culture in bioreactors. 7. Summarize key mechanobiological aspects of tissue culture. 										
4	Prerequisite	e for	participation								
5	Form of exa Module exar • Modul Facultative: Will be anno etc.).	n: e exa oral unce	a ation am (Technical ex (30 min) or wri ed at the beginnir	xamination, Oral/v tten (60 min) ng of the term depo	written ez ending on	aminatio the circur	n, Default RS) nstances (numb	per of	students, par	ndemic	
6	Prerequisite Passing the e	e for exan	the award of c nination.	redit points							
7	Grading Module exar • Modul	n: e exa	am (Technical ex	amination, Oral/	written ex	aminatio	n, Weighting: 1	00 %)		
8	Usability of WPB Master WPB Master	the MB PST	module II (Kernlehrvera III (Fächer aus	instaltung aus den Natur- und Ingeni	n Maschir eurwisser	enbau) Ischaft fü	r Papiertechnik)			
9	References The current (online avail	lect able)	ure notes can bo)	e downloaded fro	m moodle	e. Referer	nce is made to o	other	relevant lite	erature	
10	Comment										

7 Elective Area C: Mechanics of Earth Systems

Mo Me	Module name Mechanics of Glaciers and Ice Sheets											
Mo	dule nr.	Cr	edit points	Workload	Self-stu	dy	Module durat	tion	Module cy	vcle		
13-	E2-M008		6 CP	180 h		120 h	1 Term		Every 2. Se	emester		
Lan Eng	guage lish				Prof. DrIng. Ralf Müller, Prof. DrIng. Dominik Schillinger							
1	Courses of t	his	module		I							
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW		
	13-E2-0014-	vl	Mechanics of G	laciers and Ice Sh	eets	0			ure	3		
	13-E2-0015-	ue	Mechanics of Exercises	Glaciers and Ice	Sheets -	0		Prac	tice	1		
2	 2 Teaching content Ice sheet, ice stream-glacier systems and their dynamics Structure of ice and constitutive relations Balance equations of ice sheets and glaciers, boundary conditions and approximations Processes in ice sheets: firn densification, sliding, calving and ice sheet hydrology recent research topics in ice sheet dynamics and stability 											
3	 3 Learning objectives After successful completion of the module, students will have acquired an understanding of ice sheet and glacier dynamics and its processes, as well as having experience in applying the methods of continuum mechanics in glaciology. 											
4	Prerequisite Basic knowle	e for edge	participation in mathematics	, physics and mec	hanics.							
5	Form of exa Module exar • Module	min n: e exa	a tion am (Technical ex	amination, Oral e	examinati	on, Durat	ion: 20 Min., D	efault	RS)			
6	Prerequisite Passing the r	e for nod	the award of c ule examination	redit points								
7	Grading Module exar • Modul	n: e ex	am (Technical ex	amination, Oral e	examinati	on, Weigh	nting: 100 %)					
8	Usability of	the	module									
9	References Cuffey&Patte Greve & Blat and Environ	erso ter ' men	n, Physics of Gla Dynamics of Gla tal Mechanics" (ciers, 2010 ciers and Ice Shee AGEM), Springer,	ets' Mono 2007	graph, Sei	ries Advances ir	n Geoj	physical			
10	0 Comment											

Module name Pollutants in the Water Cycle											
Module nr. Creation 13-K8-M001 13000000000000000000000000000000000000		edit points 6 CP	Workload 180 h	Self-stu	ı dy 120 h	Module durat	ion	n Module cycle			
LanguageModeEnglishProf.					Module Prof. Dr	lule owner . Dr. Wilhelm Urban					
1	Courses of this module										
	Course nr. Course name					Workload (CP)		Теас	ching form	HPW	
	13-K8-0001-	vu	Pollutants in th Fate in the Aqu	e Water Cycle: Sou atic Environment	rces and	ces and 0			ure and tice	4	
2	 Teaching content Sources of pollutants such as wastewater, agriculture, architecture, natural sources (water born) Transformation of pollutants in aquatic systems (e.g., photo-oxidation, reactive species such as free radicals) Mobility of pollutants: Sorption and desorption processes Control strategies: E.g., water treatment, soil and engineered surfaces Critical use of literature, options and limitations of scientific literature 									licals)	
3	Learning objectives Students learn fundamentals of the fate and reactions of pollutants in the aquatic environment regarding transformation and mobility. Students will learn how molecules behave on basis of their molecular structure. Principles of technical purification processes for elimination of pollutants and prevention of their spread into the environment. Fundamental aspects in water chemistry and water/surface interface reactions (e.g., buildings, soil) will be learned.Students will practice to evaluate current papers, find major flaws and thus, sharpen their critical faw on published data								arding ucture. nto the ildings, en their		
4	Prerequisite Recommend ons, red/ox	e for ed: 1 proc	participation Knowledge in ba cesses	sic chemistry, reac	tion kine	tics, acid/	base speciation,	inter	molecular in	teracti-	
5	 Form of examination Module exam: Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) Module exam (Study achievement, Oral/written examination, p/np RS) Subject Examination: Open book written examination (90 min.) Study Achievement: Report and Presentation 										
6	Prerequisite Passing the	e for mod	the award of c ule examination	redit points (s)							
7	 Grading Module exam: Module exam (Technical examination, Examination, Weighting: 1) Module exam (Study achievement, Oral/written examination, Weighting: 0) 										
8	Usability of	the	module								
9	References										

	Schwarzenbach, R.P., Gschwend, P.M. and Imboden, D.M. (eds) (2016) Environmental organic chemistry
	von Sonntag, C. and von Gunten, U. (eds) (2012) Chemistry of ozone in water and wastewater treat- ment, IWA Publishing.
	Weingärtner, H., Teermann, I., Borchers, U., Balsaa, P., Lutze, H.V., Schmidt, T.C., Franck, E.U., Wie- gand, G., Dahmen, N., Schwedt, G., Frimmel, F.H. and Gordalla, B.C. (2016), Water, 1. Properties, Analysis, and Hydrological Cycle, Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA.
	Lutze, H.V. (2016) Treatment by oxidation processes, Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA.
10	Comment

Mo Sate	dule name ellite Geodesy	7								
Module nr.Credit pointsWorl13-H0-M0443 CP			Workload 90 h	Self-study 60 h		Module duration		Module cycle Every 2. Semester		
LanguageMEnglishD					Module DrIng.	e owner Stefan Le	einen			
1	1 Courses of this module									
Course nr.Course nameWorkload (CP)							Теа	ching form	HPW	
	13-H0-0044 13-H0-0044	13-H0-0044-vlSatellite Geodesy13-H0-0044-Satellite Geodesy - Exercise				0 0		Lect Prac	ure tice	1
	ue									
2	Hearing content Advanced GNSS processing: - GNSS standard positioning - a review - Handling of atmospheric delays - Enhanced modeling of GNSS observations - Positioning models for high accuracy Selected topics of Satellite Geodesy: - Modelling of satellite motion and Earth gravity field - Satellite gravimetry: Missions for determination of the Earth gravity field									
3	Learning objectives The students understand the essential relationships in the field of satellite geodesy. They know important satellite missions related to Earth observation and their applications. The students know GNSS signal properties, e.g. the wave propagation in the atmosphere. Based on an extended models for observations and positioning the students are capable to process GNSS observations in order to put into practise high-accuracy geodetic applications. The students are able to describe and calculate satellite motion in space. They know the relationship between satellite dynamics and the Earth gravity field and understand the methods of satellite gravimetry. The students have a deep knowledge in satellite altimetry and understand its importance in the research on								oortant GNSS etween arch on	
4	Prerequisite	e for	participation							
5	 Form of examination Module exam: Module exam (Study achievement, Homework, worksheet, p/np RS) Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) Study achievement: 4 homework assignments, distributed evenly throughout the course period, each assignment is verified by a report, all homework assignments are equally weighted 									
6	Prerequisite Passing the 1	e for nod	the award of caule examination	redit points						
7	 Grading Module exam: Module exam (Study achievement, Homework, worksheet, Weighting: 0) Module exam (Technical examination, Examination, Weighting: 1) 									
8	Usability of the module									

9	References
	Günter Seeber. Satellite Geodesy. Verlag Walter de Gruyter, 2nd edition, 2003.
	B. Hofmann-Wellenhof, K. Legat, and M. Wieser. GNSS Global Navigation Satellite Systems - GPS, GLONASS,
	Galileo & more. Springer-Verlag, 2008.
	Springer Handbook of Global Navigation Satellite Systems, edited by P. Teunissen and O. Montenbruck, Springer,
	2017.
10	Comment
-	

8 Elective Area C: Modern Materials

Module name Glass and Polymers J: Glass Structures										
Module nr. Cr 13-M3-M003		Credit points 6 CP	Workload 180 h	Self-study 120 h		Module duration 1 Term		Module cycle Every 2. Semester		
Language English				Module owner Prof. DrIng. Jens Schneider						
1	Courses of this module									
	Course nr. Course name				Workloa	ad (CP)	Теас	ching form	HPW	
	13-M3-0002- Glass and Polymers I: vu		mers I: Glass Strue	Structures 0		Lect		ure and tice	4	
2	Teaching co	ontent								
3	Learning of	ojectives								
4	 Prerequisite for participation Recommended: Statik I and II (13-M2-M001/13-M2-M002), Structural Analysis III and IV (13-M2-M003/13-M2-M004), TM I-III (13-E0-M001/13-E0-M002/13-E0-M003) 									
5	 Form of examination Module exam: Module exam (Technical examination, Oral examination, Duration: 15 Min., Default RS) Module exam (Technical examination, Examination, Duration: 90 Min., Default RS) 									
6	Prerequisite Passing the r	e for the award of c module examination	redit points (s)							
7	 Grading Module exam: Module exam (Technical examination, Oral examination, Weighting: 50 %) Module exam (Technical examination, Examination, Weighting: 50 %) 									
8	Usability of	the module								
9	References									
10	Comment It is recommended to also complete the course Glass and Polymers II: Mechanics of Polymers. However, it is possible to attend both courses independently.									

Module name Glass and Polymers II: Mechanics of Polymers											
Module nr. Cr		Cr	edit points	Workload	Self-stu	120 h	Module duration		Module cycle		
Language English					IZU h I Term Every 2. Semester Module owner Prof. Dr -Ing. Jens Schneider						
1	1 Courses of this module										
	Course nr. Course name					Workloa	ad (CP)	Теа	ching form	HPW	
	13-M2-0019-vlGlass and Polym13-M2-0021-Glass and Polym			ners II: Polymer Mechanics (ners II: Polymer Mechanics (0 0		Lecture Practice		2 2	
2	ue - Exercise Teaching content Classification of polymer materials, fundamentals of continuum mechanics (non-linear stress and strain behavior, deformation rates), material modeling (elasticity, hyperelasticity, viscosity, plasticity) with application examples and methods of measurement, damage and failure models, modeling of composite materials										
3	Learning objectives After the attendence the lecture, the students are able to classify polymer materials with respect to their mechanical behavior and select appropriate material models for the calculation of components. The students have the ability to transfer mathematical and scientific methods to technical problems. The students have the ability to develop appropriate models for new materials and composites of polymers and know the limitations of modeling										
4	Prerequisite Recommend Bauwesen (2	e for ed: [participation Technische Mech 2-M001/8)	anik II (13-E0-M0	02), Tech	nische Me	echanik III (13-1	E0-M(003), Werkst	offe im	
5	 Form of examination Module exam: Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS) 										
6	Prerequisite Passing the p	e for nod	the award of c ule examination	redit points (s)							
7	Grading Module exam: • Module exam (Technical examination, Oral examination, Weighting: 1)										
8	Usability of	the	module								
9	References Gross et al.: G. A. Holzap	Tecl ofel:	nnische Mechani Nonlinear Solid	k 4, Springer Verla Mechanics, Wiley	ag						
10	Comment It is recommended to also complete the course Glass and Polymers I: Glass Structures. However, it is possible to attend both courses individually.										
Mo Hig	dule name h Temperatur	e M	aterials Behavior	ur							
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Mo	dule nr.	Cr	edit points	Workload	Self-stu	idy	Module dura	tion	Module cy	/cle	
10- Lon	08-5120		6 CP	180 h	Module	135 П	1 Ierm		Every 2. Se	emester	
Eng	glish				Prof. Dr	Christina	a Berger, Prof. I	DrIng	g. Matthias C	Dechsner	
1	Courses of	his	module		1						
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW	
	16-08-5120-	vl	High Temperat	ure Materials Beh	aviour	0		Lect	ure	3	
2	2 Teaching content Time dependent mechanism under high temperature exposure: Creep, oxidation, and fatigue. Microstructural stability of metallic alloys: recrystallisation, recovery, grain growth and formation of precipitation High temperature strength and deformation: Governing mechanisms and modelling concepts Fatigue under high temperature exposure: Thermal fatigue; creep - fatigue interaction High temperature corrosion: Thermodynamics and kinetics of oxidation; hot gas corrosion High temperature alloys: Fe-, Co-, Ni-based alloys and intermetallics Coatings for high temperature application: Types, deposition and characterization processes Ceramics: Monolithics and Ceramic Matrix Composites										
3	 Cotalings for high temperature application. Types, terposition and characterization processes Ceramics: Monolithics and Ceramic Matrix Composites 3 Learning objectives After following this lecture the student will be able to: I. Identify and describe relevant time-dependent mechanisms under high temperature exposure. Explain microstructural evolution processes, discuss their driving force and their effect on the behaviour of materials and components Explain the mechanisms of time-dependent deformation and strength; discuss constitutive as well as phenomenological description concepts and their model assumptions and their limitations;. Estimates of a materials creep behaviour on the basis of experimental data and/or phenomenological description models. Explain fatigue processes under high temperature loading; describe the influence of creep and relaxation on the fatigue behaviour Explain thermodynamic principles and kinetic aspects of high-temperature corrosion; explain the phenomenon of hot gas corrosion Know metallic and intermetallic material systems for high-temperature applications and discuss their application limits; select materials for given fields of application in a justified manner. Explain the functions and working principles of high-temperature coatings, describe essential manufacturing processes and relevant characterisation methods. 										
4	Prerequisite Knowledge o	e for	r participation	laterials Engineer	ing (e.g. V	Werkstoffl	kunde I) recom	mend	ed		
5	Form of exa Module exa • Modul Oral (45 min	mir n: e ex 1) oi	nation am (Technical ex r written exam 6	xamination, Oral/ 0 min	written e	xaminatio	n, Default RS)				
6	Prerequisite Passing the e	e foi exan	r the award of c nination.	redit points							
7	Grading										

1	Madula avam
	 Module exam. Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
8	Usability of the module
	WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau)
	Master AE II Kernlehrveranstaltung
	WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
9	References
	Oechsner, M: Umdruck zur Vorlesung (Foliensätze)
	Maier H.J., Niendorf T., Bürgel R. (2019) Handbuch Hochtemperatur-Werkstofftechnik. Springer Vieweg,
	Wiesbaden
	Rösler J., Harders H., Bäker, M. (2019) Mechanisches Verhalten der Werkstoffe, Springer-Verlag
	Birks, N., Gerald H. Meier G.H., Pettit F.S. (2006) Introduction to the high temperature oxidation of metals.
	Cambridge University Press
10	Comment

Mo Wel	dule name ding and Wel	ding	Simulation								
Mo	dule nr.	Cre	edit points	Workload	Self-stu	dy	Module durat	ion	Module cy	/cle	
13-	I2-M003		6 CP	180 h		120 h	1 Term		Every 2. Se	emester	
Lan Ger	n guage man				Module Prof. Dr	owner Ing. Mic	hael Vormwald				
1	Courses of	this 1	module								
	Course nr.		Course name			Workloa	ad (CP)	Tea	ching form	HPW	
	13-I2-0010-s	se	Welding and W	elding Simulation		0 Seminar 4					
2	Preaching content Introduction to Multiphysics of Welding Transient Temperatur Fields Heat Effect on Melting Zone Idealised Heat Source Heat Effect on Microstructure Thermomechanical Coupling and Nonlinear Structural Behaviour Specific Problems in Welding Simulation										
3	 3 Learning objectives After completing this modul students are able to: calculate transient temperature fields, understand transformation of microstructure due to welding process, simulate the thermomechanical problem of welding, assess results of welding simulations. 										
4	Prerequisite	e for	participation								
5	Form of exa Module exa • Modul Passing the o	min n: e exa exam	ation am (Technical ex aination and a w	xamination, Paper, ritten version of tl	Duration ne presen	1: 30 Min. tation (Re	., Default RS) eferat) has to be	e deliv	vered.		
6	Prerequisite Passing the p	e for nodi	the award of c	redit points (s)							
7	Grading Module exan • Modul	n: e exa	am (Technical ex	xamination, Paper,	Weightii	ng: 1)					
8	Usability of the module										
9	References										
10	Comment										

9 Elective Area C: AI and digitalization in Mechanics

Mo Eng	Module name Engineering Informatics I										
Мо	dule nr.	Cr	edit points	Workload	Self-stu	ıdy	Module durat	ion	Module cy	vcle	
13-	F0-M003		6 CP	180 h		120 h	1 Term		Every 2. Se	emester	
Lan Eng	guage lish				Module Prof. Dr	e owner Ing. Uw	e Rüppel				
1	Courses of	this	module								
	Course nr.		Course name			Worklo	ad (CP)	Teaching form		HPW	
	13-F0-0009-	vl	Engineering In	formatics I		0		Lecture		2	
	13-F0-0010-	ue	Engineering In	formatics I - Exerc	cise	0		Prac	tice	2	
2	 Digital transformation of engineering processes (e.g. BIM, GIS); Software Engineering for engineering applications: Requirements engineering, design, data modelling, implementation, configuration and quality management, maintenance and development-process modelling; Example applications of the models and methods and models from Civil- and Environmental Engineering. Learning objectives 										
3	Learning objectives The students have the ability to autonomously specify, implement and apply domain specific engineering tasks in teamwork with scientific computational methods and models.										
4	Prerequisite for participation Recommended: Basic knowledge in Engineering Informatics.										
5	Form of examination Module exam: • Module exam (Study achievement, Oral/written examination, p/np RS) • Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS) Subject Examination: Oral Examination (45 min.) / Written Examination (90 min.) As a rule, the examination takes the form of an oral examination, or a written examination if there are more participants. Study Achievement: 2 Exercise blocks (throughout and at the end of the semester) as group work										
6	Prerequisit Passing the	e fo ı mod	the award of c ule examination	redit points (s)							
7	Passing the module examination(s) Grading Module exam: • Module exam (Study achievement, Oral/written examination, Weighting: 0) • Module exam (Technical examination, Oral/written examination, Weighting: 1)										
8	Usability of	the	module								
9	References Literature w	rill b	e announced at t	the beginning of tl	ne course	•					
10	Comment	_									

Mo Eng	Module name Engineering Informatics II									
Mo 13-	dule nr. F0-M004	Cr	edit points 6 CP	Workload 180 h	Self-stu	dy 120 h	Module durat	tion	Module cy Every 2. Se	v cle emester
Lar Eng	guage lish			I	Module Prof. Dr	owner Ing. Uwe	e Rüppel			
1	Courses of t	his	module			U				
	Course nr.		Course name			Workloa	ad (CP)	Теа	ching form	HPW
	13-F0-0012- 13-F0-0011-	vl ue	Engineering In Engineering In	formatics II formatics II - Exer	cise	0		Lect Prac	ure tice	2
2	 2 Teaching content Internet of Things (IoT) sensornetworks; BigData and distributed databases; Data Mining, Machine Learning and Artificial Intelligence; Cryptography and digital signature for securing engineering applications in networks; Exemplary application of the methods and models on examples from Civil- and Environmental Engineering. 									
3	Learning objectives The students have the ability to autonomously model, implement and apply domain specific engineering tasks with scientific data centered principles in terms of Machine Learning/ Artificial Intelligence in secure computer networks. Demonstraining									
4	Prerequisite for participation Recommended: Basic knowledge in Engineering Informatics.									
5	Form of exa Module exar Modul Modul Subject Exar As a rule, th participants. Study Achie	min n: e exa nina e exa e exa	am (Technical ex am (Study achie ation: Oral Exam amination takes nent: 2 Exercise	kamination, Oral/v vement, Oral/writ ination (45 min.) the form of an ora e blocks (through	written ez ten exam / Written al examin hout and	caminatio ination, p Examina ation, or at the	on, Duration: 90 o/np RS) ation (90 min.) a written exami end of the ser	Min. inatio meste	, Default RS n if there ar r) as group) e more o work
	and Submiss	sion	Colloquium	1					, , , , , , , , , , , , , , , , , , , ,	-
6	Prerequisite Passing the 1	nod	ule examination	(s)						
7	Grading Module exar • Modul • Modul	n: e exa e exa	am (Technical ex am (Study achie	xamination, Oral/ vement, Oral/writ	written ex ten exam	kaminatio ination, V	on, Weighting: 1 Weighting: 0))		
8	Usability of the module									
9	References Literature w	ill be	e announced at t	he beginning of th	ne course					
10	0 Comment									

Mo Mat	Module name Mathematics of Machine Learning										
Mo 04-	dule nr. 10-0598	Cr	edit points 4 CP	Workload 120 h	Self-stu	dy 120 h	Module durat	tion	Module cy Every 2. Se	z cle emester	
Lan	guage	I			Module	owner	Ian Ciasaalmaa				
Ger	man Courses of a	1. : -			Prof. Dr	. rer. nat.	Jan Glesselman	In			
1	Courses of Course nr.	inis	Course name			Workloa	ad (CP)	Теас	hing form		
	04-10-0598-	vu	Mathematics of	f Machine Learnin	g	0		Lectu pract	ure and tice	0	
2	 2 Teaching content 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 objectives 										
3	 3 Learning objectives 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	Prerequisite Mathematics	e for s I-II	participation I recommended								
5	Form of exa Module exa • Modul	n: e ex	nation am (Technical ez	xamination, Exam	ination, I	Ouration:	45 Min., Defaul	t RS)			
6	Prerequisite Passing the f	e for final	the award of c module examination	redit points ation							
7	Grading Module exan • Modul	n: e ex	am (Technical ex	xamination, Exam	ination, V	Veighting	: 100 %)				
8	Usability of Bachelor ME	the 3 cor	module npulsory								
9	References 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 Comment										
	0 Comment										

Mo Phy	dule name sics-Aware M	achi	ne Learning							
Mo 16-	dule nr. 73-4144	Cr	edit points 6 CP	Workload 180 h	Self-stu	l dy 120 h	Module durat	tion	Module cy Every 2. Se	z cle emester
Lar Eng	i guage Ilish				Module Prof. Dr	e owner . rer. nat.	Oliver Weeger			
1	Courses of	this	module							
	Course nr.		Course name			Worklo	ad (CP)	Tead	ching form	HPW
	16-73-4144-	vl	Physics Aware	Machine Learning	, ,	0		Lect	ure	3
2	 2 Teaching content Physics-aware machine learning (ML) combines classical, physics-based modeling approaches with ML methods to improve the generalization capabilities, interpretability, robustness, reliability and efficiency of ML methods in engineering applications Introduction to ML methods and their essential theoretical properties, including in particular artificial neural networks (approximation capabilities, training, gradients, etc.) Foundations of physics-based modeling and simulation using differential equations and suitable temporal and spatial discretization methods (time integration and finite elements) Physics-based and data-driven model order reduction and surrogate modeling (e.g. modal analysis, orthogonal decompositions, kriging, kernel methods, etc.) Mathematical knowledge representations of conservation equations & quantities, symmetries, invariances, etc. for physics-aware ML Construction principles for informing or augmenting ML methods through appropriate design of training data, hypotheses for input and output variables of ML models, ML model architectures, or learning or training algorithms Methods include e.g. Sobolev training, convex & monotonic NNs, physics informed NNs (PINNs), Langrangian NNs, neural operators, stochastic NNs, recurrent NNs, convolutional NNs, graph NNs, autoencoders, generative NNs, Gaussian processes & kernel methods, etc. 									
3	Learning of On successfu 1. Know and simulation 2. Mathema invariances 3. Describe, 4. Explain a networks for 5. Describe efficiency of	bject al co l ide tical and expl nd e r var and phys	tives mpletion of this ntify possible ap ly formalize phy solvability requi- lain and discuss evaluate suitable ious fields of app explain the impo- sics-aware ML co	module, students plications for physical and mathem rements basic approaches a physics-informed plication roved generalization pncepts	should bo sics-awar atical pro and algor and phy on capab	e able to: e machin operties su ithms of p sics-augn ilities, int	e learning in en uch as energy co physics-aware M nented model a cerpretability, ro	nginee onserv IL rchite obustr	ering modeli vation, symm ectures with ness, reliabili	ng and netries, neural ity and
4	Prerequisite Basic knowle equations, ti	e for edge ime i	participation on machine lean integration, finite	rning, physical mo e elements) is reco	delling ar	nd numer ed	ical simulation	(in pa	rticular diffe	erential
5	 Form of examination Module exam: Module exam (Technical examination, Oral/written examination, Default RS) Written exam (90 min) or oral exam (30 min) 									
6	Prerequisite	e for	the award of c	redit points						

	Passing the examination
7	Grading Module exam:
	Module exam (Technical examination, Oral/written examination, Weighting: 100 %)
8	Usability of the module Master MBSE WPB II (Kernlehrveranstaltungen aus dem Maschinenbau) Master AE & BME WPB III Master Computational Engineering Master Mechanik
9	 References S.J.D. Prince: "Understanding Deep Learning", MIT Press, 2023 S. Kollmannsberger, D. Davide, M. Jokeit, L. Herrmann: "Deep Learning in Computational Mechanics", Springer, 2021 S.L. Brunton, J.N. Kutz: "Data-Driven Science and Engineering", Cambridge University Press, 2022 S. Cuomo, V.S. di Cola, F. Giampaolo, G. Rozza, M. Raissi, F. Piccialli: "Scientific Machine Learning through Physics-Informed Neural Networks: Where we are and What's next", Journal of Scientific Computing 92:88, 2022
10	Comment

Mo Sma	Module name Smart Products, Engineering & Services								
Mo 16-	dule nr. 98-4084	Credit points 6 CP	Workload 180 h	Self-stu	idy 150 h	Module durat	ion	Module cy Every 2. Se	v cle emester
Lan Eng	i guage lish			Module Prof. Dr	e owner :-Ing. Eck	hard Kirchner			
1	Courses of t	his module							
	Course nr.	Course name			Worklo	ad (CP)	Теас	ching form	HPW
	16-98-4084-	vl Smart Product	s, Engineering & S	ervices	0		Lect	ure	1
	16-98-4084-	ue Smart Product	s, Engineering & S	ervices	0		Prac	tice	1
	16-98-4084-	pj Smart Product	s, Engineering & S	ervices	0		Proj	ect	0
	Introduction to artificial intelligence (AI), big data, cyber-physical systems, and smart mechatronic systems; smart machine elements: classification, integration of sensing functions, design, evaluation and calibration of sensing elements, applicability limitations; ideation and market analysis; rapid manufacturing and tolerance management for designing test components; agile project management and hardware development, Design Review Based on Failure Mode (DRBFM); business models and market introduction of products and Product- Service-Systems; Verification and Validation (V&V)-methods: remote software updates and AI-based attribute changes during operation phase; predictive maintenance: damage prediction and monitoring; software-based lightweight development.								
3	 changes during operation phase; predictive maintenance: damage prediction and monitoring; software-based lightweight development. 3 Learning objectives On successful completion of this module, students should be able to: Understand the basics of AI, Big Data and Cyber-Physical Systems, describe self-learning user-oriented system and Smart Mechatronic Systems and understand their implications for the development phase; and being able to apply the basics in a developmental software environment. Analyze the requirements of smart sensing elements of a smart product followed by the design and evaluation of a product concept. Classify smart machine elements and explain the procedures of sensor integration and sensor calibration. Explain the basics of innovation management, know methods for idea generation and idea sources, identify customer needs, select and analyze market segments. Identify the limits of sensor concepts and assess the limits of their applicability. Understand and apply rapid manufacturing technologies for the fast production of test components, know typical disturbances and perform tolerance management. Perform agile management (Scrum), agile hardware engineering and understand DRBFM. Explain the basics of adoption and diffusion of innovation, and master Business Model Frameworks, Business Model Innovation, and innovation of Product-Service-Systems. 8. Explain V&V methods and understand the implications of remote software updates and machine learning based attribute changes during operation phase incl. user feedback and Safety issues. 9. Explain the concept of predictive maintenance, differentiate between damage prediction and damage monitoring during the operation phase and know the associated methods 								
4	Prerequisite Programmin	e for participation g skills Matlab / Pyt	hon benefitial.						
5	Programming skills Matlab / Python benefitial. Form of examination Module exam: • Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) Course related exam: • [16-98-4084-pj] (Technical examination, Presentation, Default RS) Written exam (60 min., 60 %) and Presentation of the prototype with proof of function and discussion (40 %).								

6	Prerequisite for the award of credit points Passing the examinations
7	 Grading Module exam: Module exam (Technical examination, Examination, Weighting: 60 %) Course related exam: [16-98-4084-pj] (Technical examination, Presentation, Weighting: 40 %)
8	Usability of the module Master MB Ib Digitalisierung WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
9	References Lecture and recitation material via moodle.
10	Comment Lecturers: Prof. DrIng. S. Rinderknecht, Prof. DrIng. E. Kirchner and Prof. Dr. A. Kock (FB 1)

10 Elective Area C: Mechanics of Aeronatics and Astronautics

Mo Avie	Module name Avionics System Safety										
Mo	dule nr.	Cr	edit points	Workload	Self-stu	00 h	Module dura	tion	Module cy	cle	
Lan Eng	guage lish		+ 61	120 11	Module Prof. Dr	e owner Ing. Uw	e Klingauf				
1	Courses of	this	module							_	
	Course nr.		Course name			Worklo	ad (CP)	Теа	ching form	HPW	
	16-23-5110-	vl	Avionics System	n Safety		0		Lect	ure	2	
2	Teaching co Operational design of sat	onter requ fe sy	nt 1irements for flig stems, pilot assis	sht guidance syste stance systems in t	ms, struc the cockp	ture of flig it, humar	ght guidance sy 1 factors.	stems	s, architectur	res and	
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Describe the basics of automated flight operations and human-machine interfaces in modern aircraft flight decks. 2. Explain the basic concepts and methods in the design of safety critical systems in flight control. 3. Differentiate between the different system architecture concepts. 4. Describe and discuss the complex interplay of technical systems, operational processes and humans using the example of avionics systems. 										
4	Prerequisite for participation Recommended: Flight Mechanics I: Performance, Fundamentals of Navigation I, Systemic Evaluation of Air Transportation										
5	Form of exa Module exa • Modul Written exa	min n: e ex n 60	ation am (Technical ex min or oral exa	kamination, Oral/ m 20 min	written ex	xaminatio	n, Default RS)				
6	Prerequisit Passing the	e for exan	the award of c nination	redit points							
7	Grading Module exan • Modul	n: e ex	am (Technical ex	kamination, Oral/	written ez	kaminatio	on, Weighting: 1	00 %)		
8	Usability of WPB Master Master AE II WPB Master	the MB Ker PST	module II (Kernlehrvera nlehrveranstaltu ' III (Fächer aus	instaltung aus den ng Natur- und Ingeni	n Maschir eurwisser	1enbau) nschaft fü	ir Papiertechnik	:)			
9	 References Bahr, N.J.: System Safety Engineering and Risk Assessment: A Practical Approach, 2ndEdition, CRC Press 2015Dhillon, B.S.: Transportation Systems Reliability and Safety, CRC Press 2011C.C. Rodriges, S.K. Cusick: Commercial Aviation Safety, McGraw Hill 2011R. Isermann: Fault Diagnosis Systems. Springer 2006 										
10	Comment										

Mo Flig	dule name tht Mechanics	II: D	Dynamics							
Mo	dule nr.	Cre	edit points	Workload	Self-stu	dy	Module durat	tion	Module cy	vcle
10 Lan	23-5040		6 CP	180 h	Module	135 h	1 Ierm		Every 2. Se	emester
Eng	glish				Prof. Dr	Ing. Uw	e Klingauf			
1	Courses of	this 1	module							
	Course nr.		Course name			Workloa	ad (CP)	Tead	ching form	HPW
	16-23-5040-	-vl	Flight Mechani	cs II: Dynamics		0		Lect	ure	3
2	Teaching co Static stabil lateral stabi	onter ity of lity; e	nt flight; static lo eigenvalues; 6-d	ngitudinal and lat egrees-of-freedom	eral moti n model	on; stead	y maneuvers; d	ynam	ic longitudir	nal and
3	 3 Learning objectives On successful completion of this module, students should be able to: 1. Model, analyse, and characterize the static and dynamic motion of aircrafts. 2. Explain the impact of the aircraft configuration on system behavior. 3. Evaluate the handling qualities. 4. Design control surfaces for the control of flight state. 5. Design models for flight simulation. 									
4	Prerequisite for participation Flight Mechanics I and Control Engineering recommended									
5	Form of exa Module exa • Modul Written exa	mina m: e exa m 90	ation am (Technical ex min or oral exa	kamination, Oral/ m 30 min	written ex	kaminatio	n, Default RS)			
6	Prerequisit Passing the	e for exam	the award of c ination	redit points						
7	Grading Module exan • Modul	m: e exa	um (Technical e	kamination, Oral/	written ez	xaminatio	n, Weighting: 1	.00 %)	
8	Usability of WPB Master Master AE II WPB Master Master Mecl	the MB Kerr PST hatro	module II (Kernlehrvera nlehrveranstaltu III (Fächer aus nik	instaltung aus der ing Natur- und Ingeni	n Maschir eurwisser	nenbau) nschaft fü	r Papiertechnik)		
9	9 References Course notes and further material available online. Textbooks: Anderson: Introduction to Flight (McGraw Hill);Yechout: Introduction to Aircraft Flight Mechanics (AIAA); Stevens, Lewis: Aircraft Control and Simulation (Wiley); Cook: Flight Dynamics Principles (Elsevier); Etkin, Reid: Dynamics of Flight: Stability and Control (Wiley).									
10	Comment									

Mo Fur	dule name damentals of	Spa	ce Systems							
Mo	dule nr. 23-3134	Cro	edit points	Workload	Self-stu	dy 90 h	Module durat	tion	ion Module cycle	
Language English				120 11	Module owner Prof. DrIng. Reinhold Bertrand					
1	1 Courses of this module									
	Course nr. Course name				Workload (CP)			Teaching form		HPW
	16-23-3134-	16-23-3134-vl Fundamentals of Space Systems						Lecture 2		2
2	Teaching content The lecture shall present the basics to understand, design and operate space systems, in particular: Historical development of spaceflight, utilisation of space, space environment, Ziolkowsky equation, foundations of orbit mechanics and maneuvers, overview on subsystems for space systems: energy provision, attitude and orbit control, thermal control, data handling and communication.								storical of orbit d orbit	
3	 Learning objectives On successful completion of this module, students should be able to: Explain the historical development of space flight with the relevant technological and societal connections, together with the respective applications and utilisation scenarios. Describe, characterise and estimate the relevant environmental factors for space systems (e.g. thermal environment, residual atmosphere, particle radiation etc.). Describe basic orbit manoeuvres. 									
4	Prerequisite for participation									
5	 Form of examination Module exam: Module exam (Technical examination, Oral/written examination, Default RS) Facultative: oral (20 min) or written (45 - 60 min) 									
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points						
7	Grading Module exam: • Module exam (Technical examination, Oral/written examination, Weighting: 100 %)									
8	Usability of the module WPB Master MB II (Kernlehrveranstaltung aus dem Maschinenbau) Master AE II Kernlehrveranstaltung WPB Master PST III (Fächer aus Natur- und Ingenjeurwissenschaft)									
9	References Messerschm Messerschm	id/Fa	asoulas: Raumfa ertrand: Raumst	hrtsysteme, Spring ationen - Systeme	ger Verlag e und Nut	g - e-book zung, Spr	inger Verlag			
10) Comment									

Module name Global Satellite Navigation Systems and Orbit Determination										
Module nr. Credi			edit points 4 CP	Workload 120 h	Self-study 90 h		Module durat	ion	Module cy Every 2, Se	v cle
Language				Module	owner	- 1 1		1 2001 2000		
Eng	lish Courses of t	hia	modulo		Prof. Dr	. Werner l	Enderle			
1	Course nr. Course name					Workload (CP)			ching form	HDW
	16-23-3204-vlGlobal Satellite Navigation Systems and Orbit Determination0							Lecture		2
2	Teaching content The lecture addresses selected topics of high-precision applications of global satellite navigation systems (GNSS) at the example of the European navigation systems EGNOS and Galileo: • Time reference • Geodetic reference of Galileo • Galileo and EGNOS architectures • Signals • Navigation messages • Obsestration equations for multi-GNSS • Algorithms for PVT determination based on multi-GNSS measurements • Precise point positioning • High-precision orbit determination of satellites									
	 On successful completion of this module, students should be able to: 1. Explain the structure of global satellite navigation systems, their applications and components. 2. Explain the relations between localisation requirements, navigation, and the geoscience disciplines (e.g. Geodetic reference systems, Time reference, Earth rotation, Gravitational potential etc.) 3. Evaluate the performance and contributions of GNSS and to conceptualise GNSS applications. 4. Apply the basic equations for satellite navigation, orbit determination and modelling in post-processing and analysis software. 								es (e.g. ng and	
4	Prerequisite	e for	participation							
5	 Form of examination Module exam: Module exam (Technical examination, Examination, Duration: 60 Min., Default RS) 									
6	Prerequisite Passing the	e for exan	the award of c	redit points						
7	Grading Module exam: • Module exam (Technical examination, Examination, Weighting: 100 %)									
8	Usability of the module WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master AE III Nat_Ing-Bereich									
9	References									

	Hofmann-Wellenhof, Lichtenegger, Wasle: GNSS - Global Navigation Satellite Systems. Springer-Verlag Misra, Enge: Global Positioning System, Signals, Measurements and Performance. 2nd Edition. Ganga-						
	Press. 2006. Ley, Wittmann, Hallmann (Hrsg.): Handbuch der Raumfahrttechnik. 4. Aufl. 2011. Car kHanser-Verlag						
10	Comment						

Module name Space Debris - Risks, Surveillance and Mitigation										
Module nr. (16-23-3164		Cr	edit points 4 CP	Workload 120 h	Self-stu	i dy 90 h	Module durat	tion	on Module cycle Every 2. Semester	
Language Mod English Dr. I				Module Dr. Ing.	e owner Holger Ki	rag				
1	Courses of this module									
	Course nr. Course name				Workload (CP)		Теа	ching form	HPW	
	16-23-3164-	6-23-3164-vl Space Debris - Risks, Surveillance and Mit- igation				0		Lecture		2
2	2 Teaching content This lecture will provide the scientific, technical and operational background in relation to the sources, surveillance and mitigation of space debris. This covers risk assessment aspects: source and sink terms, particle flux models, aerodynamics and aerothermal aspects during atmospheric re-entry and related on-ground risk assessments; all major aspects of space surveillance: ground-based radar and telescope systems, orbit determination methods (batch least square, Levenberg-Marquardt, Kalmanfilter), residuals, covariances, operational collision avoidance; As well as space debris mitigation aspects: long-term environment projection models, international guidelines						ources, hermal tethods idance; delines, es;			
3	 Learning objectives On successful completion of this module, students should be able to: name the sources of space debris and describe the human-made particle environment and the consequences of particle impacts; analyse and determine the risks to a space mission due the natural and human-made particle environment and limit this this risk by suitable technical measures; determine the on-ground risk caused by the atmospheric re-entry of a space object; lay-out a space mission according to applicable space debris mitigation guidelines and verify the resulting setup along with international standards; perform the main tasks of flight dynamics in operations (orbit determination and manoeuvre-planning) and explain the operational processes in the context of collision avoidance; Present the main technical aspects of space surveillance, lay-out the required sensor systems and apply the 									
4	Prerequisite knowledge o requisite.	e for of th	participation the content of "Sp	oace Flight Mecha	nics" (m	odule no.	16-25-5130) is	s an a	asset but not	t a pre-
5	 Form of examination Module exam: Module exam (Technical examination, Oral examination, Duration: 20 Min., Default RS) 									
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points						
7	 7 Grading Module exam: • Module exam (Technical examination, Oral examination, Weighting: 100 %) 									
8	Usability of	the	module							

	WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master AE III Nat_Ing-Bereich WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik)
9	References Klinkrad: Space Debris - Models and Risk Analysis, Springer Springer Praxis Books Astronautical Engineering, 2006, ISBN 978-3-540-37674-3
10	Comment

Module name Space Flight Mechanics												
Mo 16-2	dule nr. 23-4234	Cr	edit points 6 CP	Workload 180 h	Self-study 120 h		Module duration		n Module cycle Winter term			
Language English					Module DrIng.	Module owner DrIng. Florian Renk						
1 Courses of this module												
	Course nr.Course nameWorklop							Теа	ching form	HPW		
	16-23-4234-	vl	Space Flight M	echanics	0		Lect	ture	3			
2	 2 Teaching content Kepler's laws, two-body problem; satellite orbits and orbital elements, perturbation of the orbital elements; orbital transfer manoeuvres, interplanetary trajectories, the three-body problem and current missions and trajectory design problems of the European space program. 								ments; ns and			
3	 3 Learning objectives On successful completion of this module, students should be able to: Describe the orbit of spacecraft by means of geometric analysis, algebraic, and eventually numeric analysis. Explain the basic laws of celestial mechanics such as the applicability and constraints of Keplerian elements and the methods to calculate perputation. Use the principle of the patched conics approach for trajectory design. Describe the challenges and capabilities of planetary and inter-planetary space flight. Understand and apply the operational constraints that can affect the trajectory design. Name and apply the special nomenclature and system of units that appear in celestial mechanics. Name recent and older project and missions of space flight, especially with respect to the European space 											
4	Prerequisite Recommend	e for ed:	participation Successful partic	ripation in the cou	rse/exam	ination "I	Foundations of	Space	Stations"			
5	 Form of examination Module exam: Module exam (Technical examination, Oral/written examination, Default RS) Written final exam (90 min) or oral exam 20 min. 											
6	Prerequisite Passing the e	e for exan	the award of c nination	redit points								
7	 Grading Module exam: Module exam (Technical examination, Oral/written examination, Weighting: 100 %) 											
8	Usability of the module WPB Master MB III (Wahlfächer aus Natur- und Ingenieurwissenschaft) WPB Master AE III Nat_Ing-Bereich WPB Master PST III (Fächer aus Natur- und Ingenieurwissenschaft für Papiertechnik) Mechatronik											
9	References Course read	er, a	vailable in the fi	rst lecture								
10	0 Comment											