Karlsruher Institut für Technologie

Module Handbook
Techno-Mathematics Master 2016 (Master of Science (M.Sc.))

SPO 2016

Winter semester 2025/26

Date: 21/07/2025

KIT DEPARTMENT OF MATHEMATICS

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1 Study Program Structure

Mandatory	
Master's Thesis	30 CP
Internship *This field will not influence the calculated grade of its parent.*	10 CP
Applied Mathematics	24 CP
Technical Field (Election: 1 item)	
Electrical Engineering / Information Technology	18-27 CP
Experimental Physics	18-27 CP
Chemical and Process Engineering	18-27 CP
Wildcard Technical Field	18-27 CP
Mandatory	
Computer Science	8-17 CP
Mathematical Specialization	19 CP
Interdisciplinary Qualifications *This field will not influence the calculated grade of its parent.*	2 CP
Voluntary	
Additional Examinations *This field will not influence the calculated grade of its parent.*	

1.1 Master's Thesis

Credits
30

Mandatory				
M-MATH-102917	Master's Thesis		WS+SS	30 CP

1.2 Internship

Credits
10

Mandatory				
M-MATH-102861	Internship		WS+SS	10 CP

1.3 Applied Mathematics

Credits
24

Mandatory				
M-MATH-102891	Finite Element Methods		WS	8 CP
Analysis (Election: at least 8 credits)				
M-MATH-101320	Functional Analysis		WS	8 CP
M-MATH-101768	Spectral Theory	DE	SS	8 CP
M-MATH-102870	Classical Methods for Partial Differential Equations		WS	8 CP
M-MATH-102871	Boundary and Eigenvalue Problems		SS	8 CP
M-MATH-102872	Evolution Equations	DE/EN	see notes	8 CP
M-MATH-102874	Integral Equations		Irreg.	8 CP
M-MATH-102875	Models of Mathematical Physics		Irreg.	8 CP
M-MATH-102876	Boundary value problems for nonlinear differential equations		Irreg.	8 CP
M-MATH-102877	Nonlinear Evolution Equations	DE/EN	Irreg.	8 CP
M-MATH-102878	Complex Analysis		Irreg.	8 CP
M-MATH-102879	Potential Theory		Irreg.	8 CP
M-MATH-102880	Spectral Theory of Differential Operators		Irreg.	8 CP
M-MATH-102881	Stochastic Differential Equations		Irreg.	8 CP
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems		Irreg.	8 CP
M-MATH-102884	Scattering Theory		Irreg.	8 CP
M-MATH-102885	Maxwell's Equations		Irreg.	8 CP
M-MATH-102886	Nonlinear Functional Analysis		Irreg.	3 CP
M-MATH-102887	Monotonicity Methods in Analysis		Irreg.	3 CP
M-MATH-102890	Inverse Problems		WS	8 CP
M-MATH-102913	Banach Algebras		Irreg.	3 CP
M-MATH-102918	Internet Seminar for Evolution Equations	DE/EN	WS	8 CP
M-MATH-102923	Geometric Analysis		Irreg.	8 CP
M-MATH-102924	Optimization in Banach Spaces		Irreg.	5 CP
M-MATH-102926	Sobolev Spaces	DE/EN	Irreg.	8 CP
M-MATH-102927	Traveling Waves	EN	Irreg.	6 CP
M-MATH-102941	Control Theory	DE/EN	Irreg.	6 CP
M-MATH-103080	Dynamical Systems	DE	Irreg.	8 CP
M-MATH-103259	Bifurcation Theory		Irreg.	5 CP
M-MATH-103251	Aspects of Geometric Analysis		Irreg.	4 CP
M-MATH-103539	Nonlinear Analysis		Irreg.	8 CP
M-MATH-103544	Infinite dimensional dynamical systems		Irreg.	4 CP
M-MATH-104059	Mathematical Topics in Kinetic Theory		Irreg.	4 CP
M-MATH-104425	Dispersive Equations		Irreg.	6 CP
M-MATH-104435	Selected Topics in Harmonic Analysis		Irreg.	3 CP
M-MATH-104827	Fourier Analysis and its Applications to PDEs		Irreg.	6 CP
M-MATH-105066	Nonlinear Maxwell Equations	DE/EN	Irreg.	8 CP
M-MATH-105101	Introduction to Homogeneous Dynamics		Irreg.	6 CP
M-MATH-105093	Variational Methods		Irreg.	8 CP
M-MATH-105324	Harmonic Analysis		Irreg.	8 CP
M-MATH-105326	Nonlinear Wave Equations	DE/EN	Irreg.	4 CP
M-MATH-105432	Discrete Dynamical Systems	DE	Irreg.	3 CP
M-MATH-105487	Topological Data Analysis		Irreg.	6 CP
M-MATH-105650	Introduction to Fluid Dynamics		Irreg.	3 CP
M-MATH-105651	Applications of Topological Data Analysis		Irreg.	4 CP
M-MATH-105964	Introduction to Convex Integration	EN	Irreg.	3 CP
M-MATH-106401	Introduction to Fluid Mechanics	EN	Irreg.	6 CP
M-MATH-106486	Harmonic Analysis 2	EN	Irreg.	8 CP

M-MATH-106591	Introduction to Dynamical Systems	DE/EN	Irreg.	6 CP
M-MATH-106667	Geometric Variational Problems	DE/EN	Irreg.	8 CP
M-MATH-106666	Minimal Surfaces	DE	Irreg.	3 CP
M-MATH-106664	Scattering Theory for Time-dependent Waves	DE/EN	Irreg.	6 CP
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations	EN	Irreg.	6 CP
M-MATH-106696	Regularity for Elliptic Operators	EN	Irreg.	6 CP
M-MATH-106822	Advanced Methods in Nonlinear Partial Differential Equations	EN	Irreg.	3 CP
M-MATH-107456	Interpolation Spaces neu	DE/EN	Irreg.	6 CP
Elective Field Applied Mathematics (Election: at least 8 credits)				
M-MATH-102864	Convex Geometry		Irreg.	8 CP
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems		Irreg.	8 CP
M-MATH-102890	Inverse Problems		WS	8 CP
M-MATH-102898	Multigrid and Domain Decomposition Methods		Once	4 CP
M-MATH-102904	Brownian Motion		Irreg.	4 CP
M-MATH-102909	Mathematical Statistics		WS	8 CP
M-MATH-102931	Numerical Methods for Maxwell's Equations		Irreg.	6 CP
M-MATH-102936	Functions of Operators		Irreg.	6 CP
M-MATH-102947	Probability Theory and Combinatorial Optimization		Irreg.	8 CP
M-MATH-102956	Forecasting: Theory and Practice	EN	Irreg.	8 CP
M-MATH-102866	Geometry of Schemes		Irreg.	8 CP
M-MATH-102872	Evolution Equations	DE/EN	see notes	8 CP
M-MATH-102879	Potential Theory		Irreg.	8 CP
M-MATH-102888	Numerical Methods for Differential Equations		WS	8 CP
M-MATH-102906	Generalized Regression Models		Irreg.	4 CP
M-MATH-102910	Nonparametric Statistics		Irreg.	4 CP
M-MATH-102913	Banach Algebras		Irreg.	3 CP
M-MATH-102924	Optimization in Banach Spaces		Irreg.	5 CP
M-MATH-102927	Traveling Waves	EN	Irreg.	6 CP
M-MATH-101724	Algebraic Geometry		Irreg.	8 CP
M-MATH-101768	Spectral Theory	DE	SS	8 CP
M-MATH-102867	Geometric Group Theory		see notes	8 CP
M-MATH-102894	Numerical Methods in Computational Electrodynamics		Irreg.	6 CP
M-MATH-102899	Optimisation and Optimal Control for Differential Equations		Irreg.	4 CP
M-MATH-102918	Internet Seminar for Evolution Equations	DE/EN	WS	8 CP
M-MATH-102930	Numerical Methods for Integral Equations		Irreg.	8 CP
M-MATH-102941	Control Theory	DE/EN	Irreg.	6 CP
M-MATH-101315	Algebra		see notes	8 CP
M-MATH-102874	Integral Equations		Irreg.	8 CP
M-MATH-102876	Boundary value problems for nonlinear differential equations		Irreg.	8 CP
M-MATH-102905	Percolation		Irreg.	5 CP
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab	DE/EN	SS	4 CP
M-MATH-101725	Algebraic Number Theory		Irreg.	8 CP
M-MATH-102865	Stochastic Geometry		SS	8 CP
M-MATH-102881	Stochastic Differential Equations		Irreg.	8 CP
M-MATH-102915	Numerical Methods for Hyperbolic Equations		Irreg.	6 CP
M-MATH-102921	Geometric Numerical Integration		Irreg.	6 CP
M-MATH-102950	Combinatorics	EN	see notes	8 CP
M-MATH-102953	Algebraic Topology II		Irreg.	8 CP
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces		Irreg.	5 CP
M-MATH-101317	Differential Geometry		see notes	8 CP

M-MATH-102870	Classical Methods for Partial Differential Equations		WS	8 CP
M-MATH-102871	Boundary and Eigenvalue Problems		SS	8 CP
M-MATH-102900	Adaptive Finite Elemente Methods		Irreg.	8 CP
M-MATH-102903	Spatial Stochastics		WS	8 CP
M-MATH-102920	Special Topics of Numerical Linear Algebra	EN	see notes	8 CP
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations		Irreg.	8 CP
M-MATH-102932	Numerical Methods in Fluid Mechanics	EN	SS	4 CP
M-MATH-102957	Extremal Graph Theory	EN	Irreg.	4 CP
M-MATH-101320	Functional Analysis		WS	8 CP
M-MATH-101336	Graph Theory	EN	see notes	8 CP
M-MATH-101338	Parallel Computing		Irreg.	5 CP
M-MATH-102878	Complex Analysis		Irreg.	8 CP
M-MATH-102885	Maxwell's Equations		Irreg.	8 CP
M-MATH-102889	Introduction to Scientific Computing		SS	8 CP
M-MATH-102895	Wavelets		Irreg.	8 CP
M-MATH-102868	Modular Forms		Irreg.	8 CP
M-MATH-102877	Nonlinear Evolution Equations	DE/EN	Irreg.	8 CP
M-MATH-102908	Stochastic Control		Irreg.	4 CP
M-MATH-102912	Global Differential Geometry		Irreg.	8 CP
M-MATH-102935	Compressive Sensing		Irreg.	5 CP
M-MATH-102937	Functions of Matrices		Irreg.	8 CP
M-MATH-102939	Extreme Value Theory		Irreg.	4 CP
M-MATH-102943	Introduction into Particulate Flows		Once	3 CP
M-MATH-102948	Algebraic Topology	DE/EN	see notes	8 CP
M-MATH-102949	Introduction to Geometric Measure Theory		Irreg.	6 CP
M-MATH-102886	Nonlinear Functional Analysis		Irreg.	3 CP
M-MATH-102897	Mathematical Methods in Signal and Image Processing		Irreg.	8 CP
M-MATH-102901	Numerical Methods in Mathematical Finance	DE/EN	see notes	8 CP
M-MATH-102907	Markov Decision Processes		Irreg.	5 CP
M-MATH-102911	Time Series Analysis		SS	4 CP
M-MATH-102923	Geometric Analysis		Irreg.	8 CP
M-MATH-102929	Mathematical Modelling and Simulation in Practise	EN	Irreg.	4 CP
M-MATH-102860	Continuous Time Finance		SS	8 CP
M-MATH-102869	Geometric Group Theory II		Irreg.	8 CP
M-MATH-102875	Models of Mathematical Physics		Irreg.	8 CP
M-MATH-102880	Spectral Theory of Differential Operators		Irreg.	8 CP
M-MATH-102884	Scattering Theory		Irreg.	8 CP
M-MATH-102887	Monotonicity Methods in Analysis		Irreg.	3 CP
M-MATH-102892	Numerical Optimisation Methods		Irreg.	8 CP
M-MATH-102919	Discrete Time Finance		WS	8 CP
M-MATH-102922	Poisson Processes		Irreg.	5 CP
M-MATH-102926	Sobolev Spaces	DE/EN	Irreg.	8 CP
M-MATH-102954	Group Actions in Riemannian Geometry		Irreg.	5 CP
M-MATH-102959	Homotopy Theory	DE	Irreg.	8 CP
M-MATH-103260	Mathematical Methods of Imaging		Irreg.	5 CP
M-MATH-103251	Aspects of Geometric Analysis		Irreg.	4 CP
M-MATH-103527	Foundations of Continuum Mechanics		Once	4 CP
M-MATH-103539	Nonlinear Analysis		Irreg.	8 CP
M-MATH-103700	Exponential Integrators		Irreg.	6 CP
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	EN	Irreg.	5 CP

M-MATH-103919	Introduction to Kinetic Theory	EN	WS	4 CP
M-MATH-104054	Uncertainty Quantification		SS	4 CP
M-MATH-104055	Ruin Theory		Irreg.	4 CP
M-MATH-104058	Numerical Linear Algebra in Image Processing		Irreg.	6 CP
M-MATH-104059	Mathematical Topics in Kinetic Theory		Irreg.	4 CP
M-MATH-104261	Lie Groups and Lie Algebras	DE	see notes	8 CP
M-MATH-104349	Bott Periodicity		Irreg.	5 CP
M-MATH-103540	Boundary Element Methods		Irreg.	8 CP
M-MATH-105066	Nonlinear Maxwell Equations	DE/EN	Irreg.	8 CP
M-MATH-105101	Introduction to Homogeneous Dynamics		Irreg.	6 CP
M-MATH-105093	Variational Methods		Irreg.	8 CP
M-MATH-105325	Splitting Methods for Evolution Equations		Irreg.	6 CP
M-MATH-105327	Numerical Simulation in Molecular Dynamics	DE	Irreg.	8 CP
M-MATH-105579	Steins Method with Applications in Statistics		Irreg.	4 CP
M-MATH-105636	Analytical and Numerical Homogenization	EN	Irreg.	6 CP
M-MATH-105649	Fractal Geometry	DE/EN	Irreg.	6 CP
M-MATH-105764	Numerical Analysis of Helmholtz Problems	DE	Irreg.	3 CP
M-MATH-105840	Statistical Learning		SS	8 CP
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	EN	Irreg.	6 CP
M-MATH-106045	Introduction to Stochastic Differential Equations	EN	Irreg.	4 CP
M-MATH-106052	Random Graphs and Networks	EN	Irreg.	8 CP
M-MATH-106053	Stochastic Simulation	EN	WS	5 CP
M-MATH-106063	Numerical Complex Analysis	DE	Irreg.	6 CP
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	EN	SS	4 CP
M-MATH-106485	Functional Data Analysis	EN	Irreg.	4 CP
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries	EN	Irreg.	4 CP
M-MATH-106664	Scattering Theory for Time-dependent Waves	DE/EN	Irreg.	6 CP
M-MATH-106695	Numerical Analysis of Neural Networks	EN	Irreg.	6 CP
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations	DE/EN	see notes	8 CP

1.4 Electrical Engineering / Information Technology

Credits
18-27

Mandatory				
M-MATH-102863	Technomathematical Seminar		WS+SS	3 CP
Electrical Engineering / Information Technology (Election: between 15 and 24 credits)				
M-ETIT-102310	Optimal Control and Estimation	DE	SS	3 CP
M-ETIT-100371	Nonlinear Control Systems	DE	SS	3 CP
M-ETIT-100386	Electromagnetics and Numerical Calculation of Fields	EN	WS	4 CP
M-ETIT-100531	Optimization of Dynamic Systems	EN	WS	5 CP
M-ETIT-107005	Batteries, Fuel Cells, and Electrolysis neu	EN	WS	6 CP
M-ETIT-100538	Technical Optics	DE	WS	5 CP
M-ETIT-106899	Signal Processing Methods	EN	WS	6 CP
M-ETIT-106675	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	EN	SS	6 CP
M-ETIT-106778	Medical Imaging Technology	EN	SS	6 CP
M-ETIT-107344	Integrated Photonics neu	EN	WS	6 CP

1.5 Experimental Physics

Credits
18-27

Mandatory				
M-MATH-102863	Technomathematical Seminar		WS+SS	3 CP
Experimental Physics (Election: between 15 and 24 credits)				
M-PHYS-106331	Modern Experimental Physics I, Atoms, Nuclei and Molecules	DE	SS	8 CP
M-PHYS-106332	Modern Experimental Physics II, Structure of Matter	DE	WS	8 CP
M-PHYS-102053	Condensed Matter Theory I, Fundamentals and Advanced Topics	EN	WS	12 CP
M-PHYS-102054	Condensed Matter Theory I, Fundamentals	EN	WS	8 CP
M-PHYS-102075	Astroparticle Physics I	EN	WS	8 CP
M-PHYS-102089	Electronic Properties of Solids I, with Exercises	EN	WS	10 CP
M-PHYS-102090	Electronic Properties of Solids I, without Exercises	EN	WS	8 CP
M-PHYS-102097	Basics of Nanotechnology I	EN	WS	4 CP
M-PHYS-102100	Basics of Nanotechnology II	EN	SS	4 CP
M-PHYS-102108	Electronic Properties of Solids II, with Exercises	EN	SS	8 CP
M-PHYS-102109	Electronic Properties of Solids II, without Exercises	EN	SS	4 CP
M-PHYS-102114	Particle Physics I	EN	WS	8 CP
M-PHYS-102175	Introduction to Cosmology	EN	WS	6 CP
M-PHYS-102277	Theoretical Optics	EN	SS	6 CP
M-PHYS-102295	Theoretical Nanooptics	EN	Irreg.	6 CP
M-PHYS-102308	Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics	EN	SS	12 CP
M-PHYS-102313	Condensed Matter Theory II: Many-Body Theory, Fundamentals	EN	SS	8 CP

1.6 Chemical and Process Engineering

Credits
18-27

Mandatory				
M-MATH-102863	Technomathematical Seminar		WS+SS	3 CP
Chemical and Process Engineering (Election: between 15 and 24 credits)				
M-CIWVT-103051	Heat Transfer II	DE	WS	6 CP
M-CIWVT-103058	Thermodynamics III	DE	WS	6 CP
M-CIWVT-103059	Statistical Thermodynamics	DE/EN	SS	6 CP
M-CIWVT-103063	Thermodynamics of Interfaces	DE/EN	SS	4 CP
M-CIWVT-103065	Biopharmaceutical Purification Processes	DE	WS	6 CP
M-CIWVT-103066	Process Modeling in Downstream Processing	DE	SS	4 CP
M-CIWVT-103068	Physical Foundations of Cryogenics	EN	SS	6 CP
M-CIWVT-103069	Combustion Technology	DE	WS	6 CP
M-CIWVT-103072	Computational Fluid Dynamics	DE	WS	6 CP
M-CIWVT-103073	Processing of Nanostructured Particles	DE	WS	6 CP
M-CIWVT-103075	High Temperature Process Engineering	DE	SS	6 CP

1.7 Wildcard Technical Field

Credits
18-27

Mandatory				
M-MATH-102863	Technomathematical Seminar		WS+SS	3 CP

1.8 Computer Science

Credits
8-17

Computer Science (Election: at least 1 item as well as between 8 and 17 credits)				
M-INFO-100799	Formal Systems	DE	WS	6 CP
M-INFO-100803	Real-Time Systems	DE	SS	6 CP
M-INFO-104897	Robotics III - Sensors and Perception in Robotics	EN	SS	3 CP
M-INFO-100818	Computer Architecture	DE	SS	6 CP
M-INFO-100819	Cognitive Systems	DE	SS	6 CP
M-INFO-100825	Pattern Recognition	DE	SS	6 CP
M-INFO-100846	Neural Networks	DE/EN	SS	6 CP
M-INFO-100856	Computer Graphics	DE	WS	6 CP
M-INFO-100840	Localization of Mobile Agents	DE	SS	6 CP
M-INFO-101887	Seminar Advanced Topics in Parallel Programming	DE/EN	SS	3 CP
M-INFO-100829	Stochastic Information Processing	DE	WS	6 CP
M-INFO-106014	Introduction to Artificial Intelligence	DE	WS	5 CP
M-INFO-106015	Information Security	DE	SS	5 CP
M-INFO-102756	Robotics II - Humanoid Robotics	EN	SS	3 CP
M-INFO-106102	Logical Foundations of Cyber-Physical Systems	EN	WS	6 CP
M-INFO-106998	IT Security neu	EN	WS	6 CP
M-INFO-107162	Robotics I - Introduction to Robotics neu	EN	WS	6 CP
M-INFO-107197	Deep Learning and Neural Networks neu	EN	SS	6 CP
M-INFO-107235	Software Engineering II neu	EN	SS	6 CP
M-INFO-107243	Telematics neu	EN	WS	6 CP
M-INFO-107090	Sampling Methods for Machine Learning neu	EN	SS	6 CP
M-INFO-106933	Practical Course: Mathematical and Computational Methods in Robotics and AI neu	DE/EN	WS+SS	6 CP
M-INFO-106504	Simulation and Optimization in Robotics and Biomechanics neu	EN	WS	6 CP

1.9 Mathematical Specialization

Credits
19

Mandatory				
M-MATH-102730	Seminar	DE/EN	WS+SS	3 CP
Elective Field Mathematical Specialization (Election: at least 16 credits)				
M-MATH-102864	Convex Geometry		Irreg.	8 CP
M-MATH-102866	Geometry of Schemes		Irreg.	8 CP
M-MATH-102872	Evolution Equations	DE/EN	see notes	8 CP
M-MATH-102879	Potential Theory		Irreg.	8 CP
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems		Irreg.	8 CP
M-MATH-102888	Numerical Methods for Differential Equations		WS	8 CP
M-MATH-102890	Inverse Problems		WS	8 CP
M-MATH-102898	Multigrid and Domain Decomposition Methods		Once	4 CP
M-MATH-102904	Brownian Motion		Irreg.	4 CP
M-MATH-102906	Generalized Regression Models		Irreg.	4 CP
M-MATH-102909	Mathematical Statistics		WS	8 CP
M-MATH-102910	Nonparametric Statistics		Irreg.	4 CP
M-MATH-102913	Banach Algebras		Irreg.	3 CP
M-MATH-102918	Internet Seminar for Evolution Equations	DE/EN	WS	8 CP
M-MATH-102924	Optimization in Banach Spaces		Irreg.	5 CP
M-MATH-102927	Traveling Waves	EN	Irreg.	6 CP
M-MATH-102931	Numerical Methods for Maxwell's Equations		Irreg.	6 CP
M-MATH-102936	Functions of Operators		Irreg.	6 CP
M-MATH-102947	Probability Theory and Combinatorial Optimization		Irreg.	8 CP
M-MATH-102956	Forecasting: Theory and Practice	EN	Irreg.	8 CP
M-MATH-101315	Algebra		see notes	8 CP
M-MATH-101724	Algebraic Geometry		Irreg.	8 CP
M-MATH-101725	Algebraic Number Theory		Irreg.	8 CP
M-MATH-101768	Spectral Theory	DE	SS	8 CP
M-MATH-102867	Geometric Group Theory		see notes	8 CP
M-MATH-102874	Integral Equations		Irreg.	8 CP
M-MATH-102876	Boundary value problems for nonlinear differential equations		Irreg.	8 CP
M-MATH-102881	Stochastic Differential Equations		Irreg.	8 CP
M-MATH-102894	Numerical Methods in Computational Electrodynamics		Irreg.	6 CP
M-MATH-102899	Optimisation and Optimal Control for Differential Equations		Irreg.	4 CP
M-MATH-102905	Percolation		Irreg.	5 CP
M-MATH-102915	Numerical Methods for Hyperbolic Equations		Irreg.	6 CP
M-MATH-102930	Numerical Methods for Integral Equations		Irreg.	8 CP
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab	DE/EN	SS	4 CP
M-MATH-102941	Control Theory	DE/EN	Irreg.	6 CP
M-MATH-102953	Algebraic Topology II		Irreg.	8 CP
M-MATH-101317	Differential Geometry		see notes	8 CP
M-MATH-101320	Functional Analysis		WS	8 CP
M-MATH-101336	Graph Theory	EN	see notes	8 CP
M-MATH-101338	Parallel Computing		Irreg.	5 CP
M-MATH-102865	Stochastic Geometry		SS	8 CP
M-MATH-102870	Classical Methods for Partial Differential Equations		WS	8 CP
M-MATH-102871	Boundary and Eigenvalue Problems		SS	8 CP
M-MATH-102878	Complex Analysis		Irreg.	8 CP
M-MATH-102885	Maxwell's Equations		Irreg.	8 CP
M-MATH-102889	Introduction to Scientific Computing		SS	8 CP
M-MATH-102895	Wavelets		Irreg.	8 CP

M-MATH-102900	Adaptive Finite Elemente Methods		Irreg.	8 CP
M-MATH-102903	Spatial Stochastics		WS	8 CP
M-MATH-102920	Special Topics of Numerical Linear Algebra	EN	see notes	8 CP
M-MATH-102921	Geometric Numerical Integration		Irreg.	6 CP
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations		Irreg.	8 CP
M-MATH-102932	Numerical Methods in Fluid Mechanics	EN	SS	4 CP
M-MATH-102937	Functions of Matrices		Irreg.	8 CP
M-MATH-102939	Extreme Value Theory		Irreg.	4 CP
M-MATH-102943	Introduction into Particulate Flows		Once	3 CP
M-MATH-102950	Combinatorics	EN	see notes	8 CP
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces		Irreg.	5 CP
M-MATH-102957	Extremal Graph Theory	EN	Irreg.	4 CP
M-MATH-102860	Continuous Time Finance		SS	8 CP
M-MATH-102868	Modular Forms		Irreg.	8 CP
M-MATH-102869	Geometric Group Theory II		Irreg.	8 CP
M-MATH-102875	Models of Mathematical Physics		Irreg.	8 CP
M-MATH-102877	Nonlinear Evolution Equations	DE/EN	Irreg.	8 CP
M-MATH-102884	Scattering Theory		Irreg.	8 CP
M-MATH-102886	Nonlinear Functional Analysis		Irreg.	3 CP
M-MATH-102887	Monotonicity Methods in Analysis		Irreg.	3 CP
M-MATH-102897	Mathematical Methods in Signal and Image Processing		Irreg.	8 CP
M-MATH-102901	Numerical Methods in Mathematical Finance	DE/EN	see notes	8 CP
M-MATH-102907	Markov Decision Processes		Irreg.	5 CP
M-MATH-102908	Stochastic Control		Irreg.	4 CP
M-MATH-102911	Time Series Analysis		SS	4 CP
M-MATH-102912	Global Differential Geometry		Irreg.	8 CP
M-MATH-102919	Discrete Time Finance		WS	8 CP
M-MATH-102922	Poisson Processes		Irreg.	5 CP
M-MATH-102923	Geometric Analysis		Irreg.	8 CP
M-MATH-102926	Sobolev Spaces	DE/EN	Irreg.	8 CP
M-MATH-102929	Mathematical Modelling and Simulation in Practise	EN	Irreg.	4 CP
M-MATH-102935	Compressive Sensing		Irreg.	5 CP
M-MATH-102948	Algebraic Topology	DE/EN	see notes	8 CP
M-MATH-102949	Introduction to Geometric Measure Theory		Irreg.	6 CP
M-MATH-102959	Homotopy Theory	DE	Irreg.	8 CP
M-MATH-102880	Spectral Theory of Differential Operators		Irreg.	8 CP
M-MATH-102892	Numerical Optimisation Methods		Irreg.	8 CP
M-MATH-102954	Group Actions in Riemannian Geometry		Irreg.	5 CP
M-MATH-103080	Dynamical Systems	DE	Irreg.	8 CP
M-MATH-103259	Bifurcation Theory		Irreg.	5 CP
M-MATH-103260	Mathematical Methods of Imaging		Irreg.	5 CP
M-MATH-103251	Aspects of Geometric Analysis		Irreg.	4 CP
M-MATH-103527	Foundations of Continuum Mechanics		Once	4 CP
M-MATH-103539	Nonlinear Analysis		Irreg.	8 CP
M-MATH-103700	Exponential Integrators		Irreg.	6 CP
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	EN	Irreg.	5 CP
M-MATH-103919	Introduction to Kinetic Theory	EN	WS	4 CP
M-MATH-104054	Uncertainty Quantification		SS	4 CP
M-MATH-104055	Ruin Theory		Irreg.	4 CP
M-MATH-104058	Numerical Linear Algebra in Image Processing		Irreg.	6 CP

M-MATH-104059	Mathematical Topics in Kinetic Theory		Irreg.	4 CP
M-MATH-104261	Lie Groups and Lie Algebras	DE	see notes	8 CP
M-MATH-104349	Bott Periodicity		Irreg.	5 CP
M-MATH-104425	Dispersive Equations		Irreg.	6 CP
M-MATH-104435	Selected Topics in Harmonic Analysis		Irreg.	3 CP
M-MATH-104827	Fourier Analysis and its Applications to PDEs		Irreg.	6 CP
M-MATH-103540	Boundary Element Methods		Irreg.	8 CP
M-MATH-105066	Nonlinear Maxwell Equations	DE/EN	Irreg.	8 CP
M-MATH-105101	Introduction to Homogeneous Dynamics		Irreg.	6 CP
M-MATH-105093	Variational Methods		Irreg.	8 CP
M-MATH-105324	Harmonic Analysis		Irreg.	8 CP
M-MATH-105325	Splitting Methods for Evolution Equations		Irreg.	6 CP
M-MATH-105326	Nonlinear Wave Equations	DE/EN	Irreg.	4 CP
M-MATH-105327	Numerical Simulation in Molecular Dynamics	DE	Irreg.	8 CP
M-MATH-105432	Discrete Dynamical Systems	DE	Irreg.	3 CP
M-MATH-105463	Structural Graph Theory	EN	Irreg.	4 CP
M-MATH-105487	Topological Data Analysis		Irreg.	6 CP
M-MATH-105579	Steins Method with Applications in Statistics		Irreg.	4 CP
M-MATH-105636	Analytical and Numerical Homogenization	EN	Irreg.	6 CP
M-MATH-105649	Fractal Geometry	DE/EN	Irreg.	6 CP
M-MATH-105650	Introduction to Fluid Dynamics		Irreg.	3 CP
M-MATH-105651	Applications of Topological Data Analysis		Irreg.	4 CP
M-MATH-105764	Numerical Analysis of Helmholtz Problems	DE	Irreg.	3 CP
M-MATH-105837	Introduction to Kinetic Equations	EN	Irreg.	3 CP
M-MATH-105838	Introduction to Microlocal Analysis	EN	Irreg.	3 CP
M-MATH-106950	Lie-Algebras	DE	see notes	8 CP
M-MATH-105840	Statistical Learning		SS	8 CP
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	EN	Irreg.	3 CP
M-MATH-105931	Metric Geometry	DE	see notes	8 CP
M-MATH-105964	Introduction to Convex Integration	EN	Irreg.	3 CP
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	EN	Irreg.	6 CP
M-MATH-105973	Translation Surfaces	DE	Irreg.	8 CP
M-MATH-106045	Introduction to Stochastic Differential Equations	EN	Irreg.	4 CP
M-MATH-106052	Random Graphs and Networks	EN	Irreg.	8 CP
M-MATH-106053	Stochastic Simulation	EN	WS	5 CP
M-MATH-106063	Numerical Complex Analysis	DE	Irreg.	6 CP
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	EN	SS	4 CP
M-MATH-106401	Introduction to Fluid Mechanics	EN	Irreg.	6 CP
M-MATH-106466	Riemann Surfaces	DE	Irreg.	8 CP
M-MATH-106473	Ergodic Theory	DE	Irreg.	8 CP
M-MATH-106485	Functional Data Analysis	EN	Irreg.	4 CP
M-MATH-106486	Harmonic Analysis 2	EN	Irreg.	8 CP
M-MATH-106591	Introduction to Dynamical Systems	DE/EN	Irreg.	6 CP
M-MATH-106632	Curves on Surfaces	EN	Irreg.	3 CP
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries	EN	Irreg.	4 CP
M-MATH-106664	Scattering Theory for Time-dependent Waves	DE/EN	Irreg.	6 CP
M-MATH-106667	Geometric Variational Problems	DE/EN	Irreg.	8 CP
M-MATH-106666	Minimal Surfaces	DE	Irreg.	3 CP
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations	EN	Irreg.	6 CP
M-MATH-106696	Regularity for Elliptic Operators	EN	Irreg.	6 CP

M-MATH-106695	Numerical Analysis of Neural Networks	EN	Irreg.	6 CP
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations	DE/EN	see notes	8 CP
M-MATH-106776	Complex Geometry	EN	Irreg.	6 CP
M-MATH-106822	Advanced Methods in Nonlinear Partial Differential Equations	EN	Irreg.	3 CP
M-MATH-106957	Modern Methods in Combinatorics	EN	Irreg.	6 CP
M-MATH-107017	Topics in Algebraic Topology	EN	Irreg.	6 CP
M-MATH-107387	Class Field Theory neu	DE	Irreg.	8 CP
M-MATH-107484	Topics in Homotopy Theory neu	EN	Irreg.	6 CP
M-MATH-107456	Interpolation Spaces neu	DE/EN	Irreg.	6 CP

1.10 Interdisciplinary Qualifications

Credits
2

Interdisciplinary Qualifications (Election: at least 2 credits)				
M-MATH-102994	Key Competences	DE	WS+SS	2 CP

1.11 Additional Examinations

Additional Examinations (Election: at least 30 credits)				
M-MATH-101315	Algebra		see notes	8 CP
M-MATH-101317	Differential Geometry		see notes	8 CP
M-MATH-101320	Functional Analysis		WS	8 CP
M-MATH-101336	Graph Theory	EN	see notes	8 CP
M-MATH-101338	Parallel Computing		Irreg.	5 CP
M-MATH-101724	Algebraic Geometry		Irreg.	8 CP
M-MATH-101725	Algebraic Number Theory		Irreg.	8 CP
M-MATH-101768	Spectral Theory	DE	SS	8 CP
M-MATH-102730	Seminar	DE/EN	WS+SS	3 CP
M-MATH-102860	Continuous Time Finance		SS	8 CP
M-MATH-102864	Convex Geometry		Irreg.	8 CP
M-MATH-102865	Stochastic Geometry		SS	8 CP
M-MATH-102866	Geometry of Schemes		Irreg.	8 CP
M-MATH-102867	Geometric Group Theory		see notes	8 CP
M-MATH-102868	Modular Forms		Irreg.	8 CP
M-MATH-102869	Geometric Group Theory II		Irreg.	8 CP
M-MATH-102870	Classical Methods for Partial Differential Equations		WS	8 CP
M-MATH-102871	Boundary and Eigenvalue Problems		SS	8 CP
M-MATH-102872	Evolution Equations	DE/EN	see notes	8 CP
M-MATH-102874	Integral Equations		Irreg.	8 CP
M-MATH-102875	Models of Mathematical Physics		Irreg.	8 CP
M-MATH-102876	Boundary value problems for nonlinear differential equations		Irreg.	8 CP
M-MATH-102877	Nonlinear Evolution Equations	DE/EN	Irreg.	8 CP
M-MATH-102878	Complex Analysis		Irreg.	8 CP
M-MATH-102879	Potential Theory		Irreg.	8 CP
M-MATH-102880	Spectral Theory of Differential Operators		Irreg.	8 CP
M-MATH-102881	Stochastic Differential Equations		Irreg.	8 CP
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems		Irreg.	8 CP
M-MATH-102884	Scattering Theory		Irreg.	8 CP
M-MATH-102885	Maxwell's Equations		Irreg.	8 CP
M-MATH-102886	Nonlinear Functional Analysis		Irreg.	3 CP
M-MATH-102887	Monotonicity Methods in Analysis		Irreg.	3 CP
M-MATH-102888	Numerical Methods for Differential Equations		WS	8 CP
M-MATH-102889	Introduction to Scientific Computing		SS	8 CP
M-MATH-102890	Inverse Problems		WS	8 CP
M-MATH-102892	Numerical Optimisation Methods		Irreg.	8 CP
M-MATH-102894	Numerical Methods in Computational Electrodynamics		Irreg.	6 CP
M-MATH-102895	Wavelets		Irreg.	8 CP
M-MATH-102897	Mathematical Methods in Signal and Image Processing		Irreg.	8 CP
M-MATH-102898	Multigrid and Domain Decomposition Methods		Once	4 CP
M-MATH-102899	Optimisation and Optimal Control for Differential Equations		Irreg.	4 CP
M-MATH-102900	Adaptive Finite Elemente Methods		Irreg.	8 CP
M-MATH-102901	Numerical Methods in Mathematical Finance	DE/EN	see notes	8 CP
M-MATH-102903	Spatial Stochastics		WS	8 CP
M-MATH-102904	Brownian Motion		Irreg.	4 CP
M-MATH-102905	Percolation		Irreg.	5 CP
M-MATH-102906	Generalized Regression Models		Irreg.	4 CP
M-MATH-102907	Markov Decision Processes		Irreg.	5 CP
M-MATH-102908	Stochastic Control		Irreg.	4 CP

M-MATH-102909	Mathematical Statistics		WS	8 CP
M-MATH-102910	Nonparametric Statistics		Irreg.	4 CP
M-MATH-102911	Time Series Analysis		SS	4 CP
M-MATH-102912	Global Differential Geometry		Irreg.	8 CP
M-MATH-102913	Banach Algebras		Irreg.	3 CP
M-MATH-102915	Numerical Methods for Hyperbolic Equations		Irreg.	6 CP
M-MATH-102918	Internet Seminar for Evolution Equations	DE/EN	WS	8 CP
M-MATH-102919	Discrete Time Finance		WS	8 CP
M-MATH-102920	Special Topics of Numerical Linear Algebra	EN	see notes	8 CP
M-MATH-102921	Geometric Numerical Integration		Irreg.	6 CP
M-MATH-102922	Poisson Processes		Irreg.	5 CP
M-MATH-102923	Geometric Analysis		Irreg.	8 CP
M-MATH-102924	Optimization in Banach Spaces		Irreg.	5 CP
M-MATH-102926	Sobolev Spaces	DE/EN	Irreg.	8 CP
M-MATH-102927	Traveling Waves	EN	Irreg.	6 CP
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations		Irreg.	8 CP
M-MATH-102929	Mathematical Modelling and Simulation in Practise	EN	Irreg.	4 CP
M-MATH-102930	Numerical Methods for Integral Equations		Irreg.	8 CP
M-MATH-102931	Numerical Methods for Maxwell's Equations		Irreg.	6 CP
M-MATH-102932	Numerical Methods in Fluid Mechanics	EN	SS	4 CP
M-MATH-102935	Compressive Sensing		Irreg.	5 CP
M-MATH-102936	Functions of Operators		Irreg.	6 CP
M-MATH-102937	Functions of Matrices		Irreg.	8 CP
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab	DE/EN	SS	4 CP
M-MATH-102939	Extreme Value Theory		Irreg.	4 CP
M-MATH-102941	Control Theory	DE/EN	Irreg.	6 CP
M-MATH-102943	Introduction into Particulate Flows		Once	3 CP
M-MATH-102947	Probability Theory and Combinatorial Optimization		Irreg.	8 CP
M-MATH-102948	Algebraic Topology	DE/EN	see notes	8 CP
M-MATH-102949	Introduction to Geometric Measure Theory		Irreg.	6 CP
M-MATH-102950	Combinatorics	EN	see notes	8 CP
M-MATH-102953	Algebraic Topology II		Irreg.	8 CP
M-MATH-102954	Group Actions in Riemannian Geometry		Irreg.	5 CP
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces		Irreg.	5 CP
M-MATH-102956	Forecasting: Theory and Practice	EN	Irreg.	8 CP
M-MATH-102957	Extremal Graph Theory	EN	Irreg.	4 CP
M-MATH-102959	Homotopy Theory	DE	Irreg.	8 CP
M-MATH-103259	Bifurcation Theory		Irreg.	5 CP
M-MATH-103260	Mathematical Methods of Imaging		Irreg.	5 CP
M-MATH-103251	Aspects of Geometric Analysis		Irreg.	4 CP
M-MATH-104054	Uncertainty Quantification		SS	4 CP
M-MATH-104055	Ruin Theory		Irreg.	4 CP
M-MATH-104058	Numerical Linear Algebra in Image Processing		Irreg.	6 CP
M-MATH-104059	Mathematical Topics in Kinetic Theory		Irreg.	4 CP
M-MATH-103527	Foundations of Continuum Mechanics		Once	4 CP
M-MATH-103539	Nonlinear Analysis		Irreg.	8 CP
M-MATH-103700	Exponential Integrators		Irreg.	6 CP
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	EN	Irreg.	5 CP
M-MATH-103919	Introduction to Kinetic Theory	EN	WS	4 CP
M-MATH-104261	Lie Groups and Lie Algebras	DE	see notes	8 CP

M-MATH-104349	Bott Periodicity		Irreg.	5 CP
M-MATH-104425	Dispersive Equations		Irreg.	6 CP
M-MATH-104435	Selected Topics in Harmonic Analysis		Irreg.	3 CP
M-MATH-104827	Fourier Analysis and its Applications to PDEs		Irreg.	6 CP
M-MATH-103540	Boundary Element Methods		Irreg.	8 CP
M-MATH-105066	Nonlinear Maxwell Equations	DE/EN	Irreg.	8 CP
M-MATH-105101	Introduction to Homogeneous Dynamics		Irreg.	6 CP
M-MATH-105093	Variational Methods		Irreg.	8 CP
M-MATH-105324	Harmonic Analysis		Irreg.	8 CP
M-MATH-105325	Splitting Methods for Evolution Equations		Irreg.	6 CP
M-MATH-105326	Nonlinear Wave Equations	DE/EN	Irreg.	4 CP
M-MATH-105327	Numerical Simulation in Molecular Dynamics	DE	Irreg.	8 CP
M-MATH-105432	Discrete Dynamical Systems	DE	Irreg.	3 CP
M-MATH-105463	Structural Graph Theory	EN	Irreg.	4 CP
M-MATH-105487	Topological Data Analysis		Irreg.	6 CP
M-MATH-105579	Steins Method with Applications in Statistics		Irreg.	4 CP
M-MATH-105636	Analytical and Numerical Homogenization	EN	Irreg.	6 CP
M-MATH-105649	Fractal Geometry	DE/EN	Irreg.	6 CP
M-MATH-105650	Introduction to Fluid Dynamics		Irreg.	3 CP
M-MATH-105651	Applications of Topological Data Analysis		Irreg.	4 CP
M-MATH-105837	Introduction to Kinetic Equations	EN	Irreg.	3 CP
M-MATH-105838	Introduction to Microlocal Analysis	EN	Irreg.	3 CP
M-MATH-106950	Lie-Algebras	DE	see notes	8 CP
M-MATH-105840	Statistical Learning		SS	8 CP
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	EN	Irreg.	3 CP
M-MATH-105931	Metric Geometry	DE	see notes	8 CP
M-MATH-105964	Introduction to Convex Integration	EN	Irreg.	3 CP
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	EN	Irreg.	6 CP
M-MATH-105973	Translation Surfaces	DE	Irreg.	8 CP
M-MATH-106045	Introduction to Stochastic Differential Equations	EN	Irreg.	4 CP
M-MATH-106052	Random Graphs and Networks	EN	Irreg.	8 CP
M-MATH-106053	Stochastic Simulation	EN	WS	5 CP
M-MATH-106063	Numerical Complex Analysis	DE	Irreg.	6 CP
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	EN	SS	4 CP
M-MATH-106401	Introduction to Fluid Mechanics	EN	Irreg.	6 CP
M-MATH-106466	Riemann Surfaces	DE	Irreg.	8 CP
M-MATH-106473	Ergodic Theory	DE	Irreg.	8 CP
M-MATH-106485	Functional Data Analysis	EN	Irreg.	4 CP
M-MATH-106486	Harmonic Analysis 2	EN	Irreg.	8 CP
M-MATH-106591	Introduction to Dynamical Systems	DE/EN	Irreg.	6 CP
M-MATH-106632	Curves on Surfaces	EN	Irreg.	3 CP
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries	EN	Irreg.	4 CP
M-MATH-106664	Scattering Theory for Time-dependent Waves	DE/EN	Irreg.	6 CP
M-MATH-106667	Geometric Variational Problems	DE/EN	Irreg.	8 CP
M-MATH-106666	Minimal Surfaces	DE	Irreg.	3 CP
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations	EN	Irreg.	6 CP
M-MATH-106696	Regularity for Elliptic Operators	EN	Irreg.	6 CP
M-MATH-106695	Numerical Analysis of Neural Networks	EN	Irreg.	6 CP
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations	DE/EN	see notes	8 CP
M-MATH-106776	Complex Geometry	EN	Irreg.	6 CP

M-MATH-106822	Advanced Methods in Nonlinear Partial Differential Equations	EN	Irreg.	3 CP
M-FORUM-106753	Supplementary Studies on Science, Technology and Society	DE	WS+SS	16 CP
M-INFO-106102	Logical Foundations of Cyber-Physical Systems	EN	WS	6 CP
M-MATH-106957	Modern Methods in Combinatorics	EN	Irreg.	6 CP
M-MATH-107017	Topics in Algebraic Topology	EN	Irreg.	6 CP
M-MATH-107387	Class Field Theory neu	DE	Irreg.	8 CP
M-MATH-107484	Topics in Homotopy Theory neu	EN	Irreg.	6 CP
M-MATH-107456	Interpolation Spaces neu	DE/EN	Irreg.	6 CP

2 Modules

M 2.1 Module: Adaptive Finite Elemente Methods [M-MATH-102900]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-105898	Adaptive Finite Element Methods	8 CP	Dörfler

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Competence Goal
Participants

- know the necessity for using adaptive methods
- are able to explain the basic methods, techniques and algorithms for the treatment of elliptic boundary value problems with adaptive finite element methods
- can describe different approaches for error estimation
- are able to solve simple initial boundary value problems numerically

Content

- necessity of adaptive methods
- residual error estimator
- aspects of implementions
- optimality of adaptive methods
- functional error estimator
- hp-Finite Elements
- adaptivity for time-dependent problems

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research on the course content
- preparation for the module examination

Recommendations
Basic knowledge in finite element methods, in programming and analysis of boundary value problems is strongly recommended. Knowledge in functional analysis is recommended.

M 2.2 Module: Advanced Inverse Problems: Nonlinearity and Banach Spaces [M-MATH-102955]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105927	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CP	Rieder

Assessment
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Prerequisites
none

Competence Goal
Graduates are familiar with regularization methods for nonlinear ill-posed problems in Hilbert and Banach spaces and can discuss the underlying analytical and numerical aspects. They are also able to explain the conceptual differences between regularization methods in
Hilbert and Banach spaces.

Content
Inexact Newton methods in Hilbert spaces,

Approximate Inverse in Banach spaces

Tikhonov regularization with convex penalty

Kaczmarz-Newton methods in Banach spaces

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 150 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Inverse problems, Functional analysis

M 2.3 Module: Advanced Methods in Nonlinear Partial Differential Equations [M-MATH-106822]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113691	Advanced Methods in Nonlinear Partial Differential Equations	3 CP	de Rijk, Reichel

Assessment
The module examination takes place in form of an oral exam of about 30 minutes.

Prerequisites
none

Competence Goal
After successful completion of this module students

- know what amplitude or modulation equations are and can explain their significance;
- master several techniques to rigorously justify approximations by amplitude or modulation equations;
- have acquired miscellaneous methods to prove the existence of special solutions to nonlinear partial differential equations;
- can explain what the Ginzburg-Landau formalism is and how it can be employed to prove global existence of solutions.

Content
Nonlinear partial differential equations describing physical phenomena are often complex, making their qualitative and quantitative analysis challenging. Amplitude or modulation equations, such as the Ginzburg-Landau equation, the Korteweg-de Vries equation, and the nonlinear Schrödinger equation, play an important role in capturing the critical dynamics of spatially extended dissipative or conservative physical models. Mathematical theorems demonstrate that these well-understood asymptotic models accurately predict the behavior of the original system on sufficiently long time scales. Examples which can be described in such a way include pattern-forming systems close to their first instability, the long-wave limit of the water wave problem, and highly oscillatory regimes in nonlinear optics.

In the first part of this course, we develop several methods to rigorously justify approximations of complex physical systems by amplitude or modulation equations. Relevant tools include Fourier analysis, energy estimates, semigroup theory, mode filters, and normal form transformations. Often, amplitude or modulation equations admit special solutions, such as Turing patterns, solitary waves, or traveling (modulating) fronts. While approximation results yield solutions of the original system that are close to these special solutions, they are insufficient to conclude that such special solutions exist in the original system as well. In the second part of this course, we focus on techniques, such as Lyapunov-Schmidt reduction, spatial dynamics, and center manifold reduction, to construct these special solutions in the original system.

Module Grade Calculation
The module grade is the grade of the oral examination.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The following modules are recommended: Analysis 1-3, Functional Analysis, Evolution Equations

2.4 Module: Algebra [M-MATH-101315]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	see Annotations	1 term	4	2

Mandatory			
T-MATH-102253	Algebra	8 CP	Kühnlein, Sauer

Assessment
Oral examination of ca. 30 minutes.

Prerequisites
None

Competence Goal
Students are able to

- understand essential concepts from Algebra,
- apply results from Galois theory to concrete situations,
- name basic results concerning discrete valuations and relate them to integral ring extensions.

They are prepared to write a thesis on a topic from algebra.

Content

- algebraic field extensions, Galois theory, roots of unit, applications of Galois theory
- discrete valuations, discrete valuation rings
- Tensor products of modules, integral ring extensions, normalization, noetherian rings, Hilbert's Basis Theorem

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

Workload
Total worklaod : 240 hours.

Attendance: 90 h

- lectures and tutorials including the examination

Self studies: 150 h

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research on the course content
- preparation for the module examination

Recommendations
Basic knowledge on groups and rings is benefitial.

M 2.5 Module: Algebraic Geometry [M-MATH-101724]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-103340	Algebraic Geometry	8 CP	Herrlich, Kühnlein

Assessment
The module will be completed by an oral exam of about 30 minutes.

Prerequisites
None

Competence Goal
Participants are able to

- name and discuss basic concepts concerning algebraic varieties
- apply algebraic tools, in particular those from the theory of polynomial rings, to geometric questions
- explain important results from classical algebraic geometry and their application in specific examples
- start to read recent research papers from algebraic geometry and write a thesis in this area.

Content

- Hilbert's Nullstellensatz
- affine and projective varieties
- morphisms and rational maps
- non-singular varieties
- algebraic curves
- Riemann-Roch-Theorem

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total work load:

Attendance: 90 minutes

- lectures, problem classes an examination

Self studies: 150 hours

- follow-up and deepening of the course contents
- work on problem sheets
- literature study and internet research relating to the course contents
- Preparation of the oral exam

Recommendations
The contents of basic courses on algebra and number theory, including basic commutative algebra, should be well-understood.

2.6 Module: Algebraic Number Theory [M-MATH-101725]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-103346	Algebraic Number Theory	8 CP	Herrlich, Kühnlein

Assessment
oral examination of ca. 30 minutes

Prerequisites
none

Competence Goal
Students are able to

- understand basic structures and concepts from algebraic number theory,
- apply abstract concepts to concrete problems,
- read research papers and write a thesis in the field of algebraic number theory.

Content

- Algebraic number fields: rings of integers, Minkowski theory, class-groups and Dirichlet's unit theorem,
- Extensions of number fields: Ramified primes, Hilbert's ramification theory,
- Local fields: Ostrowski's theorem, valuation theory, Hensel's lemma, extensions of local fields,
- analytic methods: Dirichlet series, Dedekind's zeta function, L-series

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the module "Algebra" are strongly recommended.

2.7 Module: Algebraic Topology [M-MATH-102948]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-105915	Algebraic Topology	8 CP	Krannich, Llosa Isenrich, Sauer

Prerequisites
none

Competence Goal
Students

- are able to compute topological invariants of basic examples
- are able to work in a self-organized and reflective manner.

Content

- Basic homotopy-theoretic notions
- Examples of algebraic-topological invariants (e.g. fundamental groups or singular homology)

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

2.8 Module: Algebraic Topology II [M-MATH-102953]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105926	Algebraic Topology II	8 CP	Krannich, Sauer

Prerequisites
none

2.9 Module: Analytical and Numerical Homogenization [M-MATH-105636]

Responsible: TT-Prof. Dr. Roland Maier
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111272	Analytical and Numerical Homogenization	6 CP	Hochbruck, Maier

Assessment
Oral examination of approximately 30 minutes.

Prerequisites
None.

Competence Goal
The topic of the lecture are numerical multiscale methods presented exemplarily for elliptic problems. Students know the basic analytical results for existence and uniqueness of solutions to multiscale problems and from homogenization theory. In addition, they know methods for the numerical approximation of the multiscale and the homogenized solution. They are able to analyze the convergence of these methods and to assess the advantages and disadvantages of the different approaches.

Content

- Analytical fundamentals (basic results from analysis for elliptic partial differential equations and from homogenization theory)
- Approximation of the homogenized solution(e.g., Heterogeneous Multiscale Method)
- Approximation of the multiscale solution (e.g., Localized Orthogonal Decomposition)

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
The course is offered in English. If everybody speaks German, the lecture will be held in German.

Workload
Total workload: 180 h

Attendance: 60 h

- Course including module examination during study.

Self-studies: 120 h

- Deepening the study content by working on the lecture content at home
- Working on exercises
- In-depth study of the course content using suitable literature and Internet research,
- preparation for the module examination during study.

Recommendations
Basic knowledge of ordinary and/or partial differential equations as well as the contents of the module "Numerical Methods for Differential Equations" are strongly recommended. Knowledge of functional analysis is also recommended.

M 2.10 Module: Applications of Topological Data Analysis [M-MATH-105651]

Responsible: Dr. Andreas Ott
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-111290	Applications of Topological Data Analysis	4 CP	Ott

Prerequisites
None

2.11 Module: Aspects of Geometric Analysis [M-MATH-103251]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-106461	Aspects of Geometric Analysis	4 CP	Lamm

Assessment
oral exam; duration: about 20 minutes

Prerequisites
none

Competence Goal

- The students have got to know topics of Geometric analysis.
- They are able to use and explain the techniques they have learned in the course.

Content
Classical or recent topics of Geometric analysis, for example

- Geometric evolution equations,
- Geometric variational problems,
- The theory of minimal surfaces,
- Regularity of geometric objects,
- The isoperimetric problem,
- Spectral theory on manifolds.

Recommendations
Elementare Geometrie, Klassische Methoden partieller Differentialgleichungen/Partial differential equations, Functional analysis

M 2.12 Module: Astroparticle Physics I [M-PHYS-102075]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102432	Astroparticle Physics I	8 CP	Drexlin, Valerius

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
Students will be introduced to the basic concepts of astroparticle physics. The lecture teaches both the theoretical concepts and the experimental methods of this new dynamic field of work at the interface of elementary particle physics, cosmology and astrophysics. Students will learn to understand the concepts through concrete case studies from current research and will be enabled to apply the learned methods independently.

Methodological skills acquisition:

- Understanding of the fundamentals of experimental astroparticle physics.
- Recognition of methodological cross-connections to elementary particle physics, astrophysics, and cosmology.
- Acquisition of the ability to present a current research topic independently as well as in a team setting
- Acquisition of the ability to implement the concepts and experimental methods in the master thesis

Content
The topics covered include a general introduction to the field with its fundamental issues, theoretical concepts and experimental methods. Corresponding to the very different energy scales (meV - 1020 eV) of astroparticle physics, the lecture is divided into a discussion of the processes in the thermal (low energies) and non-thermal (high energies) universe. A special focus of the lecture is a comprehensive presentation of modern experimental techniques, e.g. in the search for very rare processes. Based on this, in the second part of the lecture a comprehensive introduction to the "dark universe" and the search for dark matter is given.

The lecture is the basis of further lectures on this topic (Astroparticle Physics II).

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises(180 hours)

Recommendations
Basic knowledge from the lecture "Nuclei and Particles".

Literature

- Donald Perkins, Particle Astrophysics (Oxford University Press, 2. Auflage, 2009)
- Claus Grupen, Astroparticle Physics (Springer, 2005)
- Lars Bergström & Ariel Goobar, Cosmology and Particle Astrophysics (Wiley, 2. Auflage, 2006)
- Malcolm Longair, High Energy Astrophysics (Cambridge University Press, 3. Auflage, 2011)

2.13 Module: Banach Algebras [M-MATH-102913]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105886	Banach Algebras	3 CP	Herzog

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
none

Competence Goal
At the end of the course, students can

- name, discuss and apply basic statements of the theory of Banach algebras,
- use specific techniques from ideal theory, spectral theory and functional calculus in Banach algebras.

Content

1. Banach and operator algebras
2. Multiplicative linear functionals
3. Spectrum and resolvents
4. Commutative Banach algebras
5. Corona Theorem
6. Functional calculus in Banach algebras
7. B*-algebras
8. Ordered Banach algebras

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Knowledge of complex analysis (e.g. from Analysis 4) is recommended.

M 2.14 Module: Basics of Nanotechnology I [M-PHYS-102097]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102529	Basics of Nanotechnology I	4 CP	Goll

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
Students deepen their knowledge in one area of nano-physics, master the relevant theoretical concepts and are familiar with basic techniques and measurement methods of nano-analytics and lithography.

Content
Introduction to central areas of nanotechnology;

Teaching of the conceptual, theoretical and, in particular, methodological fundamentals:

- Methods of imaging and characterization (nanoanalytics)
  Basic concepts of electron microscopy and associated analytical capabilities are covered in an introductory manner. Scanning probe techniques such as tunneling and force microscopy for the investigation and imaging of conductive and insulating sample surfaces, respectively, are discussed. Complementary spectroscopic capabilities of the scanning probe techniques will be explained.
- Methods of nanostructure fabrication (lithography and self-assembly)
  Along the individual process steps from coating and exposure to structure transfer by etching and vapor deposition, the methods used will be explained, their application limits discussed and current developments highlighted.

The lecture "Nanotechnology II" covers application areas and current research topics in the summer semester.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of lecture incl. exam preparation. (90 hours)

Recommendations
Basic knowledge of solid state physics and quantum mechanics is expected.

Literature
For follow-up and consolidation of the lecture material, reference is made to various textbooks as well as original and review articles. A detailed list will be given in the lecture.

M 2.15 Module: Basics of Nanotechnology II [M-PHYS-102100]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102531	Basics of Nanotechnology II	4 CP	Goll

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
The student deepens his knowledge in the field of nanophysics, masters the relevant theoretical concepts and is familiar with the basic application areas of nanophysics. The student is able to interpret current data and figures from the scientific literature and to present the current state of research as well as important "open questions".

Content
Introduction to central areas of nanotechnology

Teaching of the conceptual, theoretical and especially methodological basics;

Applications and current developments in the fields of nanoelectronics, nanooptics, nanomechanics, nanotribology, biological nanostructures, self-organized nanostructures, among others.

In addition, the lecture "Fundamentals of Nanotechnology I" in the winter semester deals with methods of imaging, characterization and fabrication of nanostructures.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (90 hours)

Recommendations
Basic knowledge of solid state physics and quantum mechanics is expected.

Literature
For follow-up and consolidation of the lecture material, reference is made to various textbooks as well as original and review articles. A detailed list will be given in the lecture.

M 2.16 Module: Batteries, Fuel Cells, and Electrolysis [M-ETIT-107005]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113986	Batteries, Fuel Cells, and Electrolysis	6 CP	Krewer

Assessment
Success control takes place in the form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
Students gain an understanding of batteries, fuel cells and electrolysis including their application, design, and behavior. They acquire in-depth knowledge of the transport and charge transfer processes in them, their impact on performance and design, and the characteristics of the most frequent types of batteries, fuel and electrolysis cells. They understand how to analyze and characterize them using measurement methods and modeling. A practical insight into current areas of application and research topics of electrochemical energy storage and conversion allows them to relate the course work to demands of the society and for R&D. They are able to communicate with specialists from related disciplines in the field of (application of) batteries, fuel cells and electrolysis and can actively contribute to the opinion-forming process in society with regard to energy technology issues.

Content
The course introduces batteries, fuel cells and electrolysis and their use for sustainable mobile and stationary energy supply and storage. The course is divided into five sections. The first part covers the role of batteries, fuel cells and electrolysis for renewable energy storage and electrification of the energy system and the present applications. This is followed by a fundamentals part, where the processes in electrochemical cells at open circuit and during operation and their relation to cell performance and behavior are discussed. It contains thermodynamics, kinetics, transport and performance measures. The third part deals with the working principle, design and operation of fuel cells and electrolysis and the particularities of the different cell types. This is followed by a similar part for batteries. Finally, dynamic and stationary methods for characterizing the cells are covered.

Group project

As part of the coursework, student groups work on the design of a battery, fuel cell or electrolyser for a given application during the semester. This includes literature research on cell type, materials and material data as well as the dimensioning and energetic evaluation of the cell. The results are documented in a short technical report.

Module Grade Calculation
The module grade is the grade of the written examination.

Workload

1. Lecture attendance time: 15 * 2 h = 30 h
2. Preparation and follow-up time for lecture: 15 * 5 h = 75 h
3. Exercise attendance time: 7 * 2 h = 14 h
4. Preparation and follow-up time for exercise: 7 * 4 h = 28 h
5. Group work including writing of a report: 33 h
6. Exam preparation and attendance: included in preparation and follow-up time.

Total: 180 h = 6 CP

M 2.17 Module: Bayesian Inverse Problems with Connections to Machine Learning [M-MATH-106328]

Responsible: Prof. Dr. Sebastian Krumscheid
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-MATH-112842	Bayesian Inverse Problems with Connections to Machine Learning	4 CP	Krumscheid

Assessment
oral exam of ca. 30 min

Prerequisites
None

Competence Goal
After completing the module's classes and the exam, students will be familiar with the theory of inverse problems. They will be able to apply the Bayesian framework to a given inverse problem and assess the
well-posedness of the Bayesian posterior. In addition, students will be able to describe the basics of several solution methods for accessing the Bayesian posterior, including approximation and machine-learning techniques, and their limitations. Finally, they will be able to name and discuss essential theoretical concepts for Bayesian inversion in Banach spaces and describe the suitable sampling-based solution techniques. In particular, the course prepares students to write a thesis in the field of Uncertainty Quantification.

Content
The course offers an introduction to the subject of statistical inversion, where, in its most basic form, the goal is to study how to estimate model parameters from data. We will introduce mathematical concepts and computational tools for systematically treating these inverse problems in a Bayesian framework, including an assessment of how uncertainties affect the solution. In the first part of the course, we will study the Bayesian framework for finite-dimensional inverse problems. While the first part will introduce some machine-learning ideas, the second part will address how machine learning is impacting, and has the potential to impact further on, the subject of inverse problems. In the final part of the course, we will generalize the Bayesian inverse problem theory to a Banach space setting and discuss sampling strategies for accessing the Bayesian posterior.

Topics covered include:

- Bayesian Inverse Problems and Well-Posedness
- The Linear-Gaussian Setting
- Optimization Perspective on Bayesian Inverse Problems
- Gaussian Approximation
- Markov Chain Monte Carlo
- Blending Inverse Problems and Machine-Learning
- Bayesian Inversion in Banach spaces

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
total workload: 120 hours

Recommendations
The contents of the modules 'M-MATH-101321 - Introduction to Stochastics', 'M-MATH-103214 – Numerical Mathematics 1+2', and 'M-MATH-106053 — Stochastic Simulation' are recommended.

2.18 Module: Bifurcation Theory [M-MATH-103259]

Responsible: Dr. Rainer Mandel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-106487	Bifurcation Theory	5 CP	Mandel

Prerequisites
None

Additional Information
Course is held in English

2.19 Module: Biopharmaceutical Purification Processes [M-CIWVT-103065]

Responsible: Prof. Dr. Jürgen Hubbuch
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106029	Biopharmaceutical Purification Processes	6 CP	Hubbuch

Assessment
The examination is a written examination with a duration of 120 minutes (section 4 subsection 2 number 1 SPO).

The grade of the written examination is the module grade.

Prerequisites
None

Competence Goal
Process development of biopharmaceutical processes

Content
Detailed discussion of biopharmaceutical purification processes

Workload

- Attendance time (Lecture): 60 h
- Homework: 90 h
- Exam Preparation: 30 h

Teaching and Learning Methods

- 22705 - Biopharmazeutische Aufarbeitungsverfahren, 3V
- 22706 - Übung zu Biopharmazeutische Aufarbeitungsverfahren, 1Ü

Literature
Vorlesungsskript

M 2.20 Module: Bott Periodicity [M-MATH-104349]

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-108905	Bott Periodicity	5 CP	Tuschmann

Prerequisites
None

M 2.21 Module: Boundary and Eigenvalue Problems [M-MATH-102871]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each summer term	1 term	4	1

Mandatory			
T-MATH-105833	Boundary and Eigenvalue Problems	8 CP	Frey, Hundertmark, Lamm, Plum, Reichel, Schnaubelt

Assessment
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- assess the significance of boundary value and eigenvalue problems within mathematics and/or physics and illustrate them using examples,
- describe qualitative properties of solutions,
- prove the existence of solutions to boundary value problems using functional analysis methods,
- make statements about the existence of eigenvalues and eigenfunctions of elliptic differential operators and describe their properties.

Content

- Examples of boundary and eigenvalue problems
- Maximum principles for 2nd order equations
- Function spaces, e.g. Sobolev spaces
- Weak formulation of 2nd order linear elliptic equations
- Existence and regularity theory for elliptic equations
- Eigenvalue theory for weakly formulated elliptic eigenvalue problems

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

M 2.22 Module: Boundary Element Methods [M-MATH-103540]

Responsible: PD Dr. Tilo Arens
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-109851	Boundary Element Methods	8 CP	Arens

Assessment
The examination is carried out by an oral examination (approx. 30 minutes).

Prerequisites
None

Competence Goal
Students are able to apply the analytic foundations of defining potentials and boundary operators, such as distributions, Sobolev spaces on boundaries of Lipschitz domains and trace operators to specific problems. They understand the definition of potentials, boundary operators and important mathematical statements about them. They are able to formulate boundary integral equations for concrete elliptic boundary value problems and to comprehend the proofs for their solvability.

Students are able to name and describe classes of boundary elements. They are familiar with the use of various boundary elements for numerically solving boundary integral equations by Galerkin methods. They can explain results on convergence of such methods. The students can describe techniques for improving practical handling of boundary element methods such as matrix compression schemes and preconditioning.

Content

- Sobolev spaces
- function spaces on Lipschitz boundaries
- boundary value problems for elliptic partial differential equations
- potentials and boundary operators
- boundary integral equations
- boundary elements
- Galerkin boundary element methods
- preconditioning
- matrix compression

Module Grade Calculation
The module grade is the grade of the oral examination.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- increased understanding of module content by wrapping up lectures at home
- work on exercises
- increased understanding of module content by self study of literature and internet research
- preparing for the examination

Recommendations
We recommend attendance of the module "Numerical Methods for Integral Equations".

M 2.23 Module: Boundary value problems for nonlinear differential equations [M-MATH-102876]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105847	Boundary Value Problems for Nonlinear Differential Equations	8 CP	Plum, Reichel

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- assess the significance of non-linear boundary value problems in relation to their applications in the natural and engineering sciences and illustrate them using examples,
- describe qualitative properties of solutions,
- prove the existence of solutions using functional analytical methods,
- recognize and analyze non-linear phenomena (e.g. bifurcation, multiplicity of solutions) and illustrate them using prototypical examples.

Content

- Method of upper and lower solutions
- Existence using fixed point methods
- Qualitative properties
- Variational methods and/or bifurcation theory

Module Grade Calculation
The module grade is the grade of the oral/written exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the courses 'Functional Analysis', 'Classical Methods for Partial Differential Equations' and 'Boundary and Eigenvalue Problems' are recommend.

2.24 Module: Brownian Motion [M-MATH-102904]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105868	Brownian Motion	4 CP	Bäuerle, Fasen-Hartmann, Last

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
none

Competence Goal
At the end of the course, students

- can name, explain and justify properties of the Brownian motion,
- can use the Brownian motion to model stochastic phenomenon,
- can use specific probabilistic techniques,
- are able to work in a self-organized and reflective manner.

Content

- Existence and construction of Brownian motion,
- path properties of Brownian motion,
- strong Markov property of Brownian motion with applications,
- Skorokhod representation theorems with Brownian motion.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures, problem classes, and examination

Self-studies: zz hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course 'Probability Theory' is strongly recommended.

2.25 Module: Class Field Theory [M-MATH-107387]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-114500	Class Field Theory	8 CP	Herrlich, Kühnlein

Assessment
The module examination takes the form of an oral examination lasting approx. 30 minutes.

Prerequisites
none

Competence Goal
Graduates

- are familiar with the issues and concepts of class field theory,
- know the basic results of class field theory and can relate them to each other,
- are prepared to write a thesis in the field of algebraic number theory

Content

- Abelian extensions of number fields, Kronecker-Weber theorem,
- Hilbert class fields, class fields for a group of ideal classes,
- Existence, completeness and isomorphism theorem for class fields,
- Dirichlet's L-series and generalization of the theorem on prime numbers in an arithmetic progression,
- Artin map and Artin's reciprocity law

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The modules "Algebra" and "Algebraic Number Theory" are strongly recommended.

M 2.26 Module: Classical Methods for Partial Differential Equations [M-MATH-102870]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	1

Mandatory			
T-MATH-105832	Classical Methods for Partial Differential Equations	8 CP	Frey, Hundertmark, Lamm, Plum, Reichel, Schnaubelt

M 2.27 Module: Cognitive Systems [M-INFO-100819]

Responsible: Prof. Dr. Gerhard Neumann
Prof. Dr. Alexander Waibel

Organisation: KIT Department of Informatics

Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101356	Cognitive Systems	6 CP	Neumann, Waibel

M 2.28 Module: Combinatorics [M-MATH-102950]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	English	4	4

Mandatory			
T-MATH-105916	Combinatorics	8 CP	Aksenovich

Assessment
The final grade is given based on the written final exam (2h).

By successfully working on the problem sets, a bonus can be obtained. To obtain the bonus, one has to achieve 50% of the points on the solutions of the exercise sheets 1-6 and also of the exercise sheets 7-12. If the grade in the final written exam is between 4,0 and 1,3, then the bonus improves the grade by one step (0,3 or 0,4).

Prerequisites
none

Competence Goal
The students understand, describe, and use fundamental notions and techniques in combinatorics. They can analyze, structure, and formally describe typical combinatorial questions. The students can use the results and methods such as inclusion-exclusion, generating functions, Young tableaux, as well as the developed proof ideas, in solving combinatorial problems. In particular, they can analyze the existence and the number of ordered and unordered arrangements of a given size. The students understand and critically use the combinatorial methods. Moreover, the students can communicate using English technical terminology.

Content
The course is an introduction into combinatorics. Starting with counting problems and bijections, classical methods such as inclusion-exclusion principle and generating functions are discussed. Further topics include Catalan families, permutations, Young tableaux, partial orders, and combinatorial designs.

Module Grade Calculation
The grade of the module ist the grade of the written exam.

Additional Information

- Course is held in English
- This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

Workload
Total workload: 240 hours

Attendance time: 90 hours

- Course including module examination during the course of study

Self-study: 150 hours

- Deepening the study content by working on the lecture content at home
- Completion of exercises
- In-depth study of the course content using suitable literature and internet research
- Preparation for the module examination during the course of study

Recommendations
Knowledge of the modules Linear Algebra 1 and 2 and Analysis 1 and 2 is recommended.

2.29 Module: Combustion Technology [M-CIWVT-103069]

Responsible: Prof. Dr.-Ing. Dimosthenis Trimis
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106104	Combustion Technology	6 CP	Trimis

Assessment
Learning Control is an oral examination with a duration of about 20 minutes (section 4 subsection 2 SPO). Grade of the module is the grade of the oral examination.

Prerequisites
None

Competence Goal

- The students are able to describe and explain the characteristics of the different flame types.
- The students can quantitatively estimate/calculate major combustion characteristics like flame temperature and flame velocity. They further understand the physicochemical mechanisms affecting flammability limits and quenching distances.
- The students understand and can assess the influence/interaction of turbulence, heat and mass transfer to reacting flows.
- The students understand the flame structure and the hierarchical structure of reaction kinetic mechanisms.
- The students understand and can assess the influence of interaction between different time scales of chemical kinetics and fluid flow in reacting flows.
- The students are able to assess and evaluate burner operability with regard to the application.

Content

- Introduction and significance of combustion technology
- Thermodynamics of combustion: Mass and energy/enthalpy balances
- Equilibrium composition
- Flame temperature
- Reaction mechanisms in combustion processes
- Laminar flame velocity and thermal flame theory
- Kinetics related combustion characteristics and experimental characterization: laminar flame velocity, flammability limits, ignition temperature, ignition energy, ignition delay time, quenching distance, flash point, octane and cetane number
- Turbulent flame propagation
- Industrial burner types

Workload

- Lectures and Exercises: 45 h
- Homework: 25 h
- Exam Preparation: 110 h

Literature

- K.K. Kuo: Principles of Combustion, John Wiley & Sons, Hoboken, New York 2005
- J. Warnatz, U. Maas, R.W. Dibble: Combustion, Spinger Verlag, Berlin, Heidelberg 2006
- S.R. Turns: An Introduction to Combustion - Concepts and Applications, McGraw-Hill, Boston 2000
- I. Glassman: Combustion, Academic Press, New York, London 1996

2.30 Module: Complex Analysis [M-MATH-102878]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105849	Complex Analysis	8 CP	Herzog, Plum, Reichel, Schnaubelt, Tolksdorf

Assessment
The module will be completed by an oral exam (about 30 min).

Prerequisites
None

Competence Goal
At the end of the course, students can

- explain the basic concepts and results of the theory of infinite products and apply them in examples within the framework of Weierstrass's theorems
- reproduce the Mittag-Leffler theorem and derive conclusions from it
- explain Riemann's mapping theorem and are able to describe what Montel's theorem is and how this theorem is included in the proof of Riemann's theorem
- name the most important properties of class S of simple functions and formulate the (proven) Bieberbach conjecture
- can explain the basic concepts of the theory of harmonic functions and apply them in examples
- explain the Schwarz reflection principle.
- describe properties of regular and singular points in power series and discuss them with examples.

Content

- infinite products
- Mittag-Leffler's theorem
- Montel's theorem
- Riemann's mapping theorem
- conformal mappings
- univalent (schlicht) functions
- automorphisms of some domains
- harmonic functions
- Schwarz reflection principle
- regular and singular points of power series

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Basics of complex analysis, for example from the “Analysis 4” module, are recommended.

2.31 Module: Complex Geometry [M-MATH-106776]

Responsible: Jun.-Prof. Dr. Claudio Llosa Isenrich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113614	Complex Geometry	6 CP	Llosa Isenrich

Assessment
The module will be completed by an oral exam (of ca. 30 min).

Prerequisites
None

Competence Goal
Graduates

- can understand the structure of complex geometry and apply its results to specific problems;
- are able to explain important results on compact Kähler manifolds and their topology, relate them to each other and apply them to examples;
- can sketch proofs of important results from the lecture;
- can work in a self-organized and reflective manner.

Content

- Introduction to complex analysis in several variables
- Complex manifolds, vector bundles and forms
- Introduction to Kähler manifolds and important examples
- The Kähler identities and their consequences
- Dolbeaut cohomology and the Hodge decomposition theorem

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Knowledge of complex analysis (e.g. "Analysis 4") and differential geometry is strongly recommended. The same applies to the contents of the modules "Elementary Geometry" and "Introduction to Algebra and Number Theory".

M 2.32 Module: Compressive Sensing [M-MATH-102935]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105894	Compressive Sensing	5 CP	Rieder

Assessment
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Competence Goal
Graduates can explain the ideas of compressive sensing and can name areas of application. They can apply and compare the basic algorithms and analyze their convergence behavior.

Content

- What is compressive sensing and where is it used?
- Sparse solutions of underdetermined linear systems of equations
- Basic algorithms
- Restricted isometry property
- Sparse solutions of underdetermined linear systems of equations with random matrices

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 150 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course "Introduction to stochastics" is recommended.

M 2.33 Module: Computational Fluid Dynamics [M-CIWVT-103072]

Responsible: Prof. Dr.-Ing. Hermann Nirschl
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106035	Computational Fluid Dynamics	6 CP	Nirschl

Assessment
Learning control is a written examination lasting 90 minutes

Prerequisites
None

Competence Goal
Learning the fundamentals of CFD for the calculation of flow problems.

Content
Navier-Stokes equitations, numerical schemes, turbulence, multiphase flows.

Module Grade Calculation
The module grade is the grade of the written examination.

Workload

- Attendance time (Lecture): 64 h
- Homework: 56 h
- Exam Preparation: 601 h

Literature

- Nirschl: Skript zur Vorlesung CFD
- Ferziger, Peric: Numerische Strömungsmechanik
- Oertel, Laurien: Numerische Strömungsmechanik

M 2.34 Module: Computational Fluid Dynamics and Simulation Lab [M-MATH-106634]

Responsible: PD Dr. Mathias Krause
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	German/English	4	2

Mandatory			
T-MATH-113373	Computational Fluid Dynamics and Simulation Lab	4 CP	Frank, Krause, Simonis, Thäter

Assessment
For their final project, students prepare a written report, usually 10-15 pages long, which is graded.

Prerequisites
none

Competence Goal
Students are able to jointly model problems beyond their own discipline and simulate them on high-performance computers. They have acquired a critical distance to results and their presentation. They can defend the results of projects in disputes. They have understood the importance of stability, convergence and parallelism of numerical methods from their own experience and are able to evaluate errors in modeling, approximation, computing and presentation.

Content
Lecture part: Introduction to modeling and simulations, introduction to associated numerical methods, introduction to associated software and high-performance computer hardware

Own group work: Working on 1-2 projects in which modelling, discretization, simulation and evaluation (e.g. visualization) are carried out for specific topics from the catalog. The catalog includes e.g: Diffusion processes, turbulent flows, multiphase flows, reactive flows, particle dynamics, optimal control and optimization under constraints, stabilization methods for advection-dominated transport problems.

Module Grade Calculation
The module grade is the grade of the final project.

Workload
Total workload: 120 hours

Attendance: 60 hours

- lectures and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on projects and report,
- literature study and internet research relating to the course content

Recommendations
Basic knowledge of the analysis of boundary value problems and of numerical methods for differential equations is recommended. Knowledge of a programming language is strongly recommened.

M 2.35 Module: Computer Architecture [M-INFO-100818]

Responsible: Prof. Dr. Wolfgang Karl
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101355	Computer Architecture	6 CP	Karl

2.36 Module: Computer Graphics [M-INFO-100856]

Responsible: Prof. Dr.-Ing. Carsten Dachsbacher
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101393	Computer Graphics	6 CP	Dachsbacher
T-INFO-104313	Computer Graphics Pass	0 CP	Dachsbacher

M 2.37 Module: Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems [M-MATH-102883]

Responsible: Prof. Dr. Michael Plum
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105854	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CP	Plum

2.38 Module: Condensed Matter Theory I, Fundamentals [M-PHYS-102054]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102559	Condensed Matter Theory I, Fundamentals	8 CP	Eder, Garst, Mirlin, Shnirman

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102053 - Condensed Matter Theory I, Fundamentals and Advanced Topics must not have been started.

Competence Goal
Gaining understanding of phenomena and concepts in condensed matter theory, mastering basic theoretical tools for their description, and acquiring the ability to analyze and solve theoretically a limited class of problems in the field of condensed matter physics.

Content
Lectures and exercises convey and deepen the basic concepts of condensed matter theory, particular attention is paid to crystalline solids. The main subjects of the lecture are:

- Crystal lattices, electrons in periodic potentials, dynamics of Bloch electrons;
- Electronic transport properties of solids, Boltzmann equation;
- Solids in an external magnetic field: Pauli paramagnetism, Landau diamagnetism, de Haas-van Alphen effect;
- Electron-electron interaction, Stoner theory of ferromagnetism;
- Landau theory of Fermi liquids; Phonons and electron-phonon interaction

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendations
Basic knowledge of solid state physics, quantum mechanics, statistical physics and thermodynamics is required.

Literature

- C. Kittel, Einführung in die Festkörperphysik (Oldenburg, 1980) / Introduction to Solid State Physics.
- C. Kittel, Quantum Theory of Solids.
- N.W. Ashcroft and N.D. Mermin, Solid State Physics (Holt, Rinehart & Winston, N.Y 1976).
- J.H. Ziman, Principles of the Theory of Solids (Cambridge, Univ. Press, 1972).
- A. A. Abrikosov, Fundamentals of the Theory of Metals

2.39 Module: Condensed Matter Theory I, Fundamentals and Advanced Topics [M-PHYS-102053]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
12 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102558	Condensed Matter Theory I, Fundamentals and Advanced Topics	12 CP	Eder, Garst, Mirlin, Shnirman

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102054 - Condensed Matter Theory I, Fundamentals must not have been started.

Competence Goal
Gaining understanding of phenomena and concepts in condensed matter theory, mastering basic theoretical tools for their description, and acquiring the ability to analyze and solve theoretically a broader class of problems in the field of condensed matter physics.

Content
Lectures and exercises convey and deepen the basic concepts of condensed matter theory, particular attention is paid to crystalline solids. The main subjects of the lecture are:

- Crystal lattices, electrons in periodic potentials, dynamics of Bloch electrons;
- Electronic transport properties of solids, Boltzmann equation;
- Solids in the external magnetic field: Pauli paramagnetism, Landau diamagnetism, de Haas-van Alphen effect;
- Electron-electron interaction, Stoner theory of ferromagnetism;
- Landau theory of Fermi liquids; Phonons and electron-phonon interaction;
- Superconductivity: BCS theory, electrodynamics of superconductors, Ginzburg-Landau theory.

Workload
360 hours consisting of attendance time (90 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (270 hours)

Recommendations
Basic knowledge of solid state physics, quantum mechanics, statistical physics and thermodynamics is required.

Literature

- C. Kittel, Einführung in die Festkörperphysik (Oldenburg, 1980) / Introduction to Solid State Physics.
- C. Kittel, Quantum Theory of Solids.
- N.W. Ashcroft and N.D. Mermin, Solid State Physics (Holt, Rinehart & Winston, N.Y 1976).
- J.H. Ziman, Principles of the Theory of Solids (Cambridge, Univ. Press, 1972).
- A. A. Abrikosov, Fundamentals of the Theory of Metals

M 2.40 Module: Condensed Matter Theory II: Many-Body Theory, Fundamentals [M-PHYS-102313]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104591	Condensed Matter Theory II: Many-Body Systems, Fundamentals	8 CP	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics must not have been started.

Competence Goal
Mastering advanced field-theoretical approaches of condensed matter physics. Acquiring an ability to apply these methods for the solution of a limited class of advanced problems in the field of condensed matter physics.

Content
Estimated structure of the lecture:

1. Green's functions for non-interacting particles
2. Many-body Green’s functions
3. Feynman diagrams (interacting fermions, Fermi fluids, collective excitations)
4. Green’s functions and diagrammatic technique at finite temperatures (Matsubara diagrammatic technique)
5. Functional formulation of many-body theory
6. Superconducting systems
7. Non-equilibrium systems and Keldysh technique
8. Many-body systems in one dimension

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation and working on the exercises (180 hours).

Recommendations
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

2.41 Module: Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics [M-PHYS-102308]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
12 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-102560	Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics	12 CP	Garst, Gornyi, Mirlin, Narozhnyy, Schmalian

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Exercises are offered to complement the lecture. Prerequisite for the participation in the oral module final examination is the passing of the course work in the exercises. The course work takes place in the form of exercises. To pass, 50% of the exercises must be passed.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals must not have been started.

Competence Goal
Mastering advanced field-theoretical approaches of condensed matter physics. Acquiring an ability to apply these methods for the solution of a broader class of advanced problems in the field of condensed matter physics.

Content
Estimated structure of the lecture:

1. Green's functions for non-interacting particles
2. Many-body Green’s functions
3. Feynman diagrams (interacting fermions, Fermi fluids, collective excitations)
4. Green’s functions and diagrammatic technique at finite temperatures (Matsubara diagrammatic technique)
5. Functional formulation of many-body theory
6. Superconducting systems
7. Non-equilibrium systems and Keldysh technique
8. Many-body systems in one dimension
9. Kondo effect
10. Strongly correlated electrons: Hubbard model and Mott metal-insulator transition
11. Introduction to mesoscopic physics

Workload
360 hours consisting of attendance time (90 hours), follow-up of the lecture incl. exam preparation and working on the exercises (270 hours)

Recommendations
In general this lecture should be attended after Theory of Condensed Matter I.

Literature

- A.A. Abrikosov, L.P. Gorkov, I.E. Dzyaloshinskii, Methods of QFT in statistical physics
- L.D. Landau, E.M. Lifschitz, Statistische Physik, Teil II (Lehrbuch der theoretischenPhysik, Bd IX)
- G.D. Mahan, Many-particle physics
- A.L. Fetter, J.D. Valecka, Quantum theory of many-particle systems.
- J.W. Negele, H. Orland, Quantum many-particle sysytems.
- J.R. Schrieffer, Theory of superconductivity.
- A. Altland, B. Simons, Condensed matter field theory.
- T. Giamarchi, Quantum physics in one dimension.
- A. Kamenev, Field theory of non-equilibrium systems.
- G. Giuliani, G. Vignale, Quantum Theory of the Electron Liquid.

2.42 Module: Continuous Time Finance [M-MATH-102860]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each summer term	1 term	4	1

Mandatory			
T-MATH-105930	Continuous Time Finance	8 CP	Bäuerle, Fasen-Hartmann, Trabs

Assessment
oral examination of ca. 30 min.

Prerequisites
The module cannot be completed together with "Stochastic Calculus and Finance [T-WIWI-103129]".

Competence Goal
Students are able to

- understand, describe and use fundamental notions and techniques of modern continuous time finance,
- use specific probabilistic techniques,
- analyze mathematically economical questions in option pricing and optimization

Content

- Stochastic processes and filtrations
  - Martingales in continuous time
  - Stopping times
  - Quadratic variation
- Stochastic Ito-Integral w.r.t. continuous semimartingales
- Ito-calculus
  - Ito-Doeblin formula
  - Stochastic exponentials
  - Girsanov theorem
  - Martingale representation
- Black-Scholes financial market
  - Arbitrage and equivalent martingale measures
  - Options and no-arbitrage prices
  - market completeness
- Portfolio optimization
- Bonds, forwards and interest rate models

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The content of the module „Probability theory“ is strongly recommended. The module „Discrete time finance“ is recommended.

2.43 Module: Control Theory [M-MATH-102941]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-105909	Control Theory	6 CP	Schnaubelt

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
none

Competence Goal
Students can explain the central concepts of the treatment of controlled linear ordinary differential equations (controllability, observability, stabilizability and discoverability) and the associated characterizations and apply them in examples. They are able to describe the basic features of the theory of transfer functions and realization theory. They can discuss the solution of the quadratic optimal control problem and apply it to feedback synthesis. They can describe the basic concepts of control theory including the associated criteria also for non-linear systems and apply them to examples.

Content

- controllabilty and observabilty of systems of linear ordinary differential equations
- stabilizability and detectability
- transfer functions
- realization theory,
- quadratic optimal control, feedback synthesis
- nonlinear controll theory: basic concepts, criteria via linearization, Lie brackets and Lyapunov functions

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the modules Analysis 1-2 und Lineare Algebra 1-2 are strongly recommended. Further knowledge of ordinary differential equations (as in Analysis 4) is useful.

Literature
J. Zabczyk, Mathematical Control Theory. An Introduction.

2.44 Module: Convex Geometry [M-MATH-102864]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105831	Convex Geometry	8 CP	Hug

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
The students

- know fundamental combinatorial, geometric and analytic properties of convex sets and convex functions and apply these to related problems,
- are familiar with fundamental geometric and analytic inequalities for functionals of convex sets and their applications to geometric extremal problems and can present central ideas and techniques of proofs,
- know selected integral formulas for convex sets and the required results on invariant measures.
- know how to work self-organized and self-reflexive.

Content

1. Convex Sets
   1.1. Combinatorial Properties
   1.2. Support and Separation Properties
   1.3. Extremal Representations
2. Convex Functions
   2.1. Basic Properties
   2.2. Regularity
   2.3. Support Function
3. Brunn-Minkowski Theory
   3.1. Hausdorff Metric
   3.2. Volume and Surface Area
   3.3. Mixed Volumes
   3.4. Geometric Inequalities
   3.5. Surface Area Measures
   3.6. Projection Functions
4. Integralgeometric Formulas
   4.1. Invariant Measures
   4.2. Projection and Section Formula
   4.3 Kinematic Formula

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload

Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam.

Literature

D. Hug, W. Weil: Lectures on Convex Geometry. Graduate Texts in Mathematics, Vol. 286, Springer, Cham, 2020.

2.45 Module: Curves on Surfaces [M-MATH-106632]

Responsible: Dr. Elia Fioravanti
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113364	Curves on Surfaces	3 CP	Fioravanti

Assessment
The module will be completed by an oral exam (of ca. 20 - 30 min).

Prerequisites
None

Competence Goal
At the end of the course, students

- have a deeper understanding of the topology and geometry of surfaces, as well as of the structure of their homeomorphisms;
- are able to work independently and critically;
- are prepared to read recent research articles and work on a thesis on mapping class groups and related topics.

Content

- curves on surfaces up to homotopy and isotopy,
- mapping class groups of surfaces,
- Nielsen-Thurston classification of homeomorphisms of surfaces,
- Teichmüller space.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the courses 'Introduction into Geometry and Topology' and 'Elementary Geometry' are recommended. The courses 'Hyperbolic Geometry' and 'Algebraic Topology' can faciliate a deeper understanding of the course contents.

M 2.46 Module: Deep Learning and Neural Networks [M-INFO-107197]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-114219	Deep Learning and Neural Networks	6 CP	Niehues

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students will learn about the structure and function of different types of neural networks.

Students should learn the methods for training the various networks and their application to problems.

Students should learn the areas of application of the different types of networks.

Given a concrete scenario, students should be able to select the appropriate type of neural network.

Content
This module introduces the use of neural networks for the solution of solving various problems in the field of machine learning, such as classification, prediction, control or inference. or inference. Different types of neural networks are covered and their areas of application are illustrated using examples.

Workload
180h.

Recommendations
Prior successful completion of the core module "Cognitive Systems" is recommended.

M 2.47 Module: Differential Geometry [M-MATH-101317]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	see Annotations	1 term	4	1

Mandatory			
T-MATH-102275	Differential Geometry	8 CP	Lytchak, Tuschmann

Prerequisites
None

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

M 2.48 Module: Discrete Dynamical Systems [M-MATH-105432]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-110952	Discrete Dynamical Systems	3 CP	Herzog

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
None

Competence Goal
At the end of the course, students can

- name, discuss and apply fundamental statements of the theory of discrete dynamic systems,
- explain the meaning of dynamic systems using examples,
- describe and use specific techniques of topological dynamics.

Content

1. Discrete dynamical systems
2. Chaotic dynamical systems
3. Non-expansive mappings
4. The Fürstenberg-Weiss theorem
5. Cellular automata
6. (Weakly) mixing dynamical systems
7. Dynamics of linear operators

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Basics of complex analysis (e.g. from Analysis 4) and functional analysis are recommended.

M 2.49 Module: Discrete Time Finance [M-MATH-102919]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	1

Mandatory			
T-MATH-105839	Discrete Time Finance	8 CP	Bäuerle, Fasen-Hartmann, Trabs

Assessment
Written exam of 2h.

Prerequisites
none

Competence Goal
Students are able to

- understand, describe and use fundamental notions and techniques of modern discrete time finance,
- use specific probabilistic techniques,
- analyze mathematically economical questions in discrete option pricing and optimization,
- work self-organized and in a reflective manner.

Content

- Finite financial markets
- The Cox-Ross-Rubinstein-model
- Limit to Black-Scholes
- Characterizing no-arbitrage
- Characterizing completeness
- Incomplete markets
- American options
- Exotic options
- Portfolio optimization
- Preferences and stochastic dominance
- Mean-Variance portfolios
- Risk measures

Module Grade Calculation
The grade of the module is the grade of the written exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The content of the module „Probability theory“ is strongly recommended.

M 2.50 Module: Dispersive Equations [M-MATH-104425]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-109001	Dispersive Equations	6 CP	Reichel

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
Graduates will be able to
- recognize the essential properties of dispersive partial differential equations and explain them using examples.
- name the particular difficulties of dispersive equations.
- use techniques to describe the short- and long-term behavior of solutions using the nonlinear Schrödinger equation as an example.
- analyze the stability of solitary waves.
- understand the concept of conservation variables and explain them for specific examples.

Content
- Strichartz estimates, Sobolev embeddings and conservation laws
- Well-posedness results
- Long-term behavior of solutions (virial and Morawetz identities)
- orbital stability of solitary waves (variational description and concentration compactness)
- Energy conservation (invariant transmission coefficients)

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the course 'Functional Analysis' are recommended.

2.51 Module: Dynamical Systems [M-MATH-103080]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-106114	Dynamical Systems	8 CP	Reichel

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
Graduates will be able to

- explain the significance of dynamical systems using examples,
- relate the concepts of a discrete-time and continuous-time dynamical system to each other,
- describe important methods for analyzing dynamical systems and use them to analyze the asymptotic behavior of solutions near equilibria for different dynamical systems,
- describe the behavior of invariant sets under discretization.

Content

- Examples of finite- and infinite-dimensional dynamical systems
- Fixed points, periodic orbits, limit sets
- Invariant sets
- Attractors
- Upper and lower continuity of attractors
- Stable and unstable manifolds
- Center manifolds

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The module 'Functional Analysis' is recommended.

M 2.52 Module: Electromagnetics and Numerical Calculation of Fields [M-ETIT-100386]

Responsible: Dr. Yongbo Deng
Prof. Dr. Ulrich Lemmer

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each winter term	1 term	English	4	3

Mandatory			
T-ETIT-100640	Electromagnetics and Numerical Calculation of Fields	4 CP	Deng, Lemmer

Assessment
Success control is carried out in the form of a written test of 120 minutes.

Prerequisites
none

Competence Goal
Students with very different background in electromagnetic field theory will be brought to a high level of comprehension. They will understand the concept of electric & magnetic fields and of electric potential & vector potential and they will be able to solve simple problems of electric & magnetic fields using mathematics. They will understand the equations and solutions of wave creation and wave propagation. Finally the student will have learnt the basics of numerical field calculation and be able to use software packages of numerical field calculation in a comprehensive and critical way.

The student will

- be able to deal with all quantities of electromagnetic field theory (E, D, B, H, J, M, P, ...), in particular: how to calculate and how to measure them,
- derive various equations from the Maxwell equations to solve simple field problems (electrostatics, magnetostatics, steady currents, electromagnetics),
- be able to deal with the concept of field energy density and solve practical problems using it (coefficients of capacitance and coefficients of inductance),
- be able to derive and use the wave equation, in particular: to solve problems how to create a wave and calculate solutions of wave propagation through various media,
- be able to outline the concepts, the main application areas and the limitations of methods of numerical field calculation (FDM, FDTD, FIM, FEM, BEM, MoM, TLM)
- be able to use one exemplary software package of numerical field calculation and solve simple practical problems with it.

Content
This course first gives a comprehensive recap of Maxwell equations and important equations of electromagnetic field theory. In the second part the most important methods of numerical field calculation are introduced.

Maxwell's equations, materials equations, boundary conditions, fields in ferroelectric and ferromagnetic materials

electric potentials, electric dipole, Coulomb integral, Laplace and Poisson's equation, separation of variables in cartesian, cylindrical and spherical coordinates

Dirichlet Problem, Neumann Problem, Greens function, Field energy density and Poynting vector,

electrostatic field energy, coefficients of capacitance, vector potential, Coulomb gauge, Biot-Savart-law, magnetic field energy, coefficients of inductance magnetic flux and coefficients of mutual inductance, field problems in steady electric currents,

law of induction, displacement current

general wave equation for E and H, Helmholtz equation

skin effect, penetration depth, eddy currents

retarded potentials, Coulomb integral with retarded potentials

wave equation for potential and Vector potential and A, Lorentz gauge, plane waves

Hertzian dipole, near field solution, far field solution

transmission lines, fields in coaxial transmission lines

waveguides, TM-waves, TE-waves

finite difference method FDM

finite difference - time domain FDTD, Yee ´s algorithm

finite difference - frequency domain

finite integration method FIM

finite element method FEM

boundary element method BEM, Method of Moments (MOM), Transmission LIne Matrix Methal (TLM),

solving large systems of linear equations

basic rules for good numerical field calculation

The lecturer reserves the right to alter the contents of the course without prior notification.

Module Grade Calculation
The module grade is the grade of the written exam.

Workload
Each credit point corresponds to approximately 25-30 hours of work (of the student). This is based on the average student who achieves an average performance. The workload includes:

Attendance time in lectures (3 h 15 appointments each) = 45 h

Self-study (4 h 15 appointments each) = 60 h

Preparation / post-processing = 20 h

Total effort approx. 125 hours = 4 LP

Recommendations
Fundamentals of electromagnetic field theory.

Literature
Matthew Sadiku (2001), Numerical Techniques in Electromagnetics.
CRC Press, Boca Raton, 0-8493-1395-3
Allen Taflove and Susan Hagness (2000), Computational electrodynamics: the finite-difference time-domain method.
Artech House, Boston, 1-58053-076-1
Nathan Ida and Joao Bastos (1997), Electromagnetics and calculation of fields.
Springer Verlag, New York, 0-387-94877-5
Z. Haznadar and Z. Stih (2000), Electromagnetic Fields, Waves and Numerical Methods.
IOS Press, Ohmsha, 1 58603 064 7
M.V.K. Chari and S.J. Salon (2000), Numerical Methods in Electromagnetism, Academic Press, 0 12 615760 X

M 2.53 Module: Electronic Properties of Solids I, with Exercises [M-PHYS-102089]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
10 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102577	Electronic Properties of Solids I, with Exercises	10 CP	Le Tacon, Wernsdorfer, Wulfhekel

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102090 - Electronic Properties of Solids I, without Exercises must not have been started.

Competence Goal
Students will be familiar with the most common experimental methods for studying the electronic properties of condensed matter and some of the key theoretical concepts that underlie them. They master the basic tools for studying and understanding heat transport, scattering mechanisms, phase transitions, and magnetism. Exercises will reinforce the acquired knowledge and apply it to classical condensed matter problems.

Content

- Metal and insulators: Band structure, Fermi surface
- Electronic and heat transport - scattering mechanisms
- Phase transitions: Landau theory, critical exponents
- Atomic magnetism and magnetic interactions
- Magnetic structures, dynamics

Additional Information
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
300 hours consisting of attendance time (75 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (225 hours)

Recommendations
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics and statistical physics is assumed.

Literature

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

M 2.54 Module: Electronic Properties of Solids I, without Exercises [M-PHYS-102090]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102578	Electronic Properties of Solids I, without Exercises	8 CP	Le Tacon, Wernsdorfer, Wulfhekel

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102089 - Electronic Properties of Solids I, with Exercises must not have been started.

Competence Goal
Students will be familiar with the most common experimental methods for studying the electronic properties of condensed matter and some of the key theoretical concepts that underlie them. They will master the basic tools for studying and understanding heat transport, scattering mechanisms, phase transitions, and magnetism.

Content

- Metal and insulators: Band structure, Fermi surface
- Electronic and heat transport - scattering mechanisms
- Phase transitions: Landau theory, critical exponents
- Atomic magnetism and magnetic interactions
- Magnetic structures, dynamics

Additional Information
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
240 hours consisting of attendance time (60 hours), wrap-up of the lecture incl. exam preparation (180 hours)

Recommendations
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics and statistical physics is assumed.

Literature

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

M 2.55 Module: Electronic Properties of Solids II, with Exercises [M-PHYS-102108]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104422	Electronic Properties of Solids II, with Exercises	8 CP	Le Tacon, Rotzinger, Ustinov, Wernsdorfer

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102109 - Electronic Properties of Solids II, without Exercises must not have been started.

Competence Goal
Students know the physical properties of superconductivity, a thermodynamic state of the electronic system of solids. They understand classical and modern experimental findings as well as basic theoretical models, such as the concept of the energy gap or the quasiparticle, which is also commonly used outside superconductivity. They apply the acquired knowledge to specific problems. The students are able to familiarize themselves with current literature on the subject of superconductivity.

Content
Foundations of superconductivity: thermodynamics, electrodynamics, flux quantization, Ginzburg-Landau theory, BCS theory, vortices, tunnel junctions, Josephson junctions, SQUIDs, superconducting electronics, superconducting qubits.

Additional Information
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (180 hours).

Recommendations
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature
- V.V. Schmidt, “The Physics of Superconductors: Introduction to Fundamentals and Applications”, Springer (1997), ISBN 978-3540612438
- M. Tinkham, „Introduction to Superconductivity: Vol I“, Dover Publ. (2004), ISBN: 978-0486435039
- W. Buckel und R. Kleiner, „Supraleitung: Grundlagen und Anwendungen“, Wiley-VCH (2004), ISBN: 978-3527403486

2.56 Module: Electronic Properties of Solids II, without Exercises [M-PHYS-102109]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104423	Electronic Properties of Solids II, without Exercises	4 CP	Le Tacon, Rotzinger, Ustinov, Wernsdorfer

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-PHYS-102108 - Electronic Properties of Solids II, with Exercises must not have been started.

Competence Goal
Students know the physical properties of superconductivity, a thermodynamic state of the electronic system of solids. They understand classical and modern experimental findings as well as basic theoretical models, such as the concept of the energy gap or the quasiparticle, which is also commonly used outside of superconductivity. Students are able to familiarize themselves with current literature on superconductivity.

Content
Foundations of superconductivity: thermodynamics, electrodynamics, flux quantization, Ginzburg-Landau theory, BCS theory, vortices, tunnel junctions, Josephson junctions, SQUIDs, superconducting electronics, superconducting qubits.

Additional Information
The course will be given in English. Questions and discussions in German are welcome as well.

Workload
120 hours consisting of attendance time (30 hours), wrap-up of the lecture incl. exam preparation (90 hours)

Recommendations
Basic knowledge of solid state physics, quantum mechanics, and thermodynamics is assumed.

Literature

- V.V. Schmidt, “The Physics of Superconductors: Introduction to Fundamentals and Applications”, Springer (1997), ISBN 978-3540612438
- M. Tinkham, „Introduction to Superconductivity: Vol I“, Dover Publ. (2004), ISBN: 978-0486435039
- W. Buckel und R. Kleiner, „Supraleitung: Grundlagen und Anwendungen“, Wiley-VCH (2004), ISBN: 978-3527403486

2.57 Module: Ergodic Theory [M-MATH-106473]

Responsible: PD Dr. Gabriele Link
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113086	Ergodic Theory	8 CP	Link

Assessment
Oral examination of ca. 20-30 minutes.

Prerequisites
None

Competence Goal
Students

- know important examples of dynamical systems,
- can state and discuss substantial concepts of ergodic theory,
- can state important results on qualitative properties of dynamical systems and relate them,
- are prepared to read recent research articles and write a bachelor or master thesis in the field of ergodic theory.

Content

- Elementary examples of dynamical systems such as Bernoulli systems and billiards
- Poincare rekurrence and ergodic theorems
- mixing, weak mixing, equidistribution
- entropy
- advanced topic(s) (as for example hyperbolic dynamics, symbolic dynamics and coding, Furstenberg correspondence principle or unitary representations of SL(2,R))

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
Some basic knowledge of measure theory, topology, geometry, group theory and functional analysis is recommended.

2.58 Module: Evolution Equations [M-MATH-102872]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-105844	Evolution Equations	8 CP	Frey, Kunstmann, Schnaubelt

Assessment
Oral examination of ca. 30 minutes.

Prerequisites
none

Competence Goal
The students

- can explain the basics of the theory of strongly continuous operator semigroups and their generators, in particular the theorems on generation and wellposedness, and they can apply it to examples.
- can also describe and use the solution and regularity theory of inhomogeneous Cauchy problems.
- are able to construct analytic semigroups and to characterize their generators. Using these results and perturbations theorems, they can solve partial differential equations.
- are able to explain main aspects of approximation theory of evolution equations.
- can discuss the core statements of stability and spectral theory of operator semigroups and discuss examples by means of them.
- have mastered the important techniques for proofs in evolution equations and are able to, at least, sketch the complicated proofs.

Content

- strongly continuous operator semigroups and their generators,
- generation results and wellposedness,
- inhomogeneous Cauchy problems,
- analytic semigroups,
- perturbation and approximation theory,
- stability and spectral theory of operator semigroups,
- applications to partial differential equations

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
Regular cycle: every 2nd year. The module "Nonlinear Evolution Equations"
is based on "Evolution Equations"

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The module “Functional Analysis” is strongly recommended.

Literature
K.-J. Engel und R. Nagel, One-Parameter Semigroups for Linear Evolution Equations.

2.59 Module: Exponential Integrators [M-MATH-103700]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-107475	Exponential Integrators	6 CP	Hochbruck, Jahnke

Assessment
Oral exam of approximately 20 minutes.

Prerequisites
None.

Competence Goal
Graduates will be able to name key concepts for the construction and analysis of exponential integrators and implement them efficiently.

Content
In this class we consider the construction, analysis, implementation and application of exponential integrators. The focus will be on two types of stiff problems.

The first one is characterized by a Jacobian that possesses eigenvalues with large negative real parts. Parabolic partial differential equations and their spatial discretization are typical examples. The second class consists of highly oscillatory problems with purely imaginary eigenvalues of large modulus.

Apart from motivating the construction of exponential integrators for various classes of problems, our main intention in this class is to present the mathematics behind these methods. We will derive error bounds that are independent of stiffness or highest frequencies in the system.

Since the implementation of exponential integrators requires the evaluation of the product of a matrix function with a vector, we will briefly discuss some possible approaches as well.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 180 h

Attendance: 60 h

- Course including module examination during study.

Self-studies: 120 h

- Deepening the study content by working on the lecture content at home
- Working on exercises
- In-depth study of the course content using suitable literature and Internet research,
- preparation for the module examination during study.

Recommendations
Basic knowledge of ordinary and/or partial differential equations as well as the contents of the module "Numerical Methods for Differential Equations" are strongly recommended. Knowledge of functional analysis is also recommended.

2.60 Module: Extremal Graph Theory [M-MATH-102957]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-MATH-105931	Extremal Graph Theory	4 CP	Aksenovich

Assessment
The final grade is given based on an oral exam (approx. 30 min.).

Competence Goal
The students understand, describe, and use fundamental notions and techniques in extremal graph theory. They can analyze, structure, and formally describe typical combinatorial questions. The students understand and use Szemeredi's regularity lemma and Szemeredi's theorem, can use probabilistic techniques, such as dependent random choice and multistep random colorings, know the best bounds for the extremal numbers of complete graphs, cycles, complete bipartite graphs, and bipartite graphs with bounded maximum degree. They understand and can use the Ramsey theorem for graphs and hypergraphs, as well as stepping-up techniques for bounding Ramsey numbers. Moreover, the students know and understand the behavior of Ramsey numbers for graphs with bounded maximum degree. The students can communicate using English technical terminology.

Content
The course is concerned with advanced topics in graph theory. It focuses on the areas of extremal functions, regularity, and Ramsey theory for graphs and hypergraphs. Further topics include Turán's theorem, Erdös-Stone theorem, Szemerédi's lemma, graph colorings and probabilistic techniques.

Additional Information
Course is held in English

Recommendations
Basic knowledge of linear algebra, analysis and graph theory is recommended.

2.61 Module: Extreme Value Theory [M-MATH-102939]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-105908	Extreme Value Theory	4 CP	Fasen-Hartmann

Assessment
The module will be completed by an oral exam (approx. 20 min).

Prerequisites
None

Competence Goal
Students are able to

- name, explain, motivate and apply statistical methods for estimating risk measures,
- model and quantify extreme events,
- apply specific probabilistic techniques of extreme value theory,
    - master proof techniques,
- work in a self-organised and reflective manner.

Content
- Theorem of Fisher and Tippett's
- Generalised extreme value and Pareto distribution (GED and GPD)
- Domain of attractions of generalised extreme value distributions
- Theorem of Pickands-Balkema-de Haan
- Estimation of risk measures
- Hill estimator
- Block maxima method
- POT method

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures and problem classes including the examination.

Self studies: 75 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature and internet research on the course content
- preparation for the module examination

Recommendations
The content of the module "Probability theory" is recommended.

M 2.62 Module: Finite Element Methods [M-MATH-102891]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (mandatory)

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	1

Mandatory			
T-MATH-105857	Finite Element Methods	8 CP	Dörfler, Hochbruck, Jahnke, Maier, Rieder, Wieners

2.63 Module: Forecasting: Theory and Practice [M-MATH-102956]

Responsible: Prof. Dr. Tilmann Gneiting
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	2 terms	English	4	2

Mandatory			
T-MATH-105928	Forecasting: Theory and Practice	8 CP	Gneiting

Prerequisites
None

Additional Information

- Regular cycle: every 2nd year, starting winter semester 16/17
- Course is held in English

M 2.64 Module: Formal Systems [M-INFO-100799]

Responsible: Prof. Dr. Bernhard Beckert
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101336	Formal Systems	6 CP	Beckert

2.65 Module: Foundations of Continuum Mechanics [M-MATH-103527]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Once	1 term	4	2

Election Notes
by interest of international students the course will be in English

Mandatory			
T-MATH-107044	Foundations of Continuum Mechanics	4 CP	Wieners

Assessment
Oral exam of approx. 20 minutes.

Prerequisites
none

Competence Goal
Graduates can

- explain the basic concepts in continuum mechanics
- distinguish different models in continuum mechanics and analyze their properties
- applying methods and principles in mathematical modelling for solids and fluids

Content

- kinematic foundations
- balance relations for static problems, Cauchy theorem
- elastic materials
- hyperelastic materials
- balance relations for dynamic probleme, Reynolds theorem
- Newtonian Fluids
- Non-Newtonian Fluids

Module Grade Calculation
the grade points are the grade points of the oral exam

Workload
in presence: 45 hours

- lecture, exercises, including exam

own study time: 75 hours

- deeper learning of the lecture content by repeating the content at home
- solving the exercises
- deeper learning by reading literature and internet
- preparation of the exam

Recommendations
optimization theory

M 2.66 Module: Fourier Analysis and its Applications to PDEs [M-MATH-104827]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	3

Mandatory			
T-MATH-109850	Fourier Analysis and its Applications to PDEs	6 CP	Liao

Prerequisites
None

2.67 Module: Fractal Geometry [M-MATH-105649]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German/English	4	2

Mandatory			
T-MATH-111296	Fractal Geometry	6 CP	Winter

Assessment
The module will be completed with an oral exam (20 - 30 min).

Prerequisites
None

Competence Goal
Students

- can name and explain important terms and concepts of fractal geometry;
- know important results of dimension theory and can apply them to examples;
- have the ability to use specific methods for the analysis of fractal structures;
- are able to construct fractals and random fractals with certain prescribed properties;
- master important proof techniques in fractal geometry and are able to at least sketch the more difficult proofs;
- are able to work self-organized and in a reflective manner;
- are prepared, to write a thesis in the field of fractal geometry.

Content

- iterated function systems and self-similar sets
- chaos game algorithm
- random fractals
- fractal dimension theory
- Hausdorff measure and dimension
- packing measure and dimension
- Minkowski contents
- methods of computing dimension
- self-similar measures and multifractals
- dimension of measures

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the courses Analysis 3 (measure theory) and Probability theory are recommended.

2.68 Module: Functional Analysis [M-MATH-101320]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	2

Mandatory			
T-MATH-102255	Functional Analysis	8 CP	Frey, Herzog, Hundertmark, Lamm, Liao, Reichel, Schnaubelt, Tolksdorf

Assessment
Written examination of 120 minutes.

Prerequisites
None

Competence Goal
The students can

- explain basic topological concepts such as compactness in the framework of metric spaces, and are able to apply these in examples.
- describe the structure of Hilbert spaces and can use them in applications.
- explain the principle of uniform boundedness, the open mapping theorem and the Hahn-Banach theorem, and are able to derive conclusions from them.
- describe the concepts of dual Banach spaces, in particular weak convergence, reflexivity and the Banach-Alaoglu theorem. They can discuss these concepts in examples.
- explain the spectral theorem for compact self-adjoint operators.
- come up with a proof for simple functional analytic statements.

Content

- Metric spaces (basic topological concepts, compactness),
- Hilbert spaces, Orthonormal bases, Sobolev spaces,
- Continuous linear operators on Banach spaces (principle of uniform boundedness, open mapping theorem),
- Dual spaces and representations, Hahn-Banach theorem, Banach-Alaoglu theorem, weak convergence, reflexivity,
- Spectral theorem for compact self-adjoint operators.

Module Grade Calculation
The grade of the module is the grade of the written exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

M 2.69 Module: Functional Data Analysis [M-MATH-106485]

Responsible: Dr. rer. nat. Bruno Ebner
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-MATH-113102	Functional Data Analysis	4 CP	Ebner, Klar, Trabs

Assessment
Oral examination of ca. 25 minutes.

Prerequisites
None

Competence Goal
The aim of the course is to give an introduction to weak convergence concepts in metric spaces and to highlight some statistical applications.

After successful participation students can

- model random elements in metric spaces,
- explain the concept of weak convergence in metric spaces and are familiar with structural problems in this context,
- apply limit laws for functionals of the empirical distribution function,
- model the normal distribution for random elements in Hilbert spaces,
- derive limit distributions of L2 type goodness-of-fit statistics,
- apply goodness-of-fit tests to functional data.

Content

- Theorem of Glivenko-Cantelli,
- weak convergence in metric spaces,
- Theorem of Prokhorov,
- Gaussian Processes,
- Donsker's Theorem,
- functional central limit theorem,
- empirical processes,
- random elements in separable Hilbert spaces,
- Goodness-of-fit tests.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 h

- lectures and examination

Self studies: 75 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the modules "Probability Theory" and "Mathematical Statistics" are strongly recommended.

M 2.70 Module: Functions of Matrices [M-MATH-102937]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105906	Functions of Matrices	8 CP	Grimm

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
The students know the basic definitions and properties of matrix functions. They can evaluate methods for approximating matrix functions in terms of convergence and efficiency, independently solve exercises, present their own solutions and implement the methods discussed.

Content

- Definition of functions of matrices
- Approximations to functions of matrices for large sparse matrices
- Krylov subspace methods and rational Krylov subspace methods
- Application to the numerical solution of partial differential equations

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The courses Numerical Analysis 1 and 2 are strongly recommended.

M 2.71 Module: Functions of Operators [M-MATH-102936]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105905	Functions of Operators	6 CP	

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
The students have basic knowledge of the approximation of functions of operators. They can examine the methods for convergence properties and efficiency. In the context of semigroups, they can analyze the procedures discussed, independently select the appropriate procedures and justify their choice.

Content

- Definition of functions of operators
- Strongly continuous and analytic semigroups
- Rational approximations to functions of operators with fixed poles
- Rational Krylov subspace method for the approximation of functions of operators
- Applications in the numerical analysis of semigroups

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The courses Numerical Analysis 1 and 2, and Functional Analysis are strongly recommended.

M 2.72 Module: Generalized Regression Models [M-MATH-102906]

Responsible: PD Dr. Bernhard Klar
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-105870	Generalized Regression Models	4 CP	Ebner, Fasen-Hartmann, Klar, Trabs

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
At the end of the course, students will

- be familiar with the most important regression models and their properties,
- be able to evaluate and interpret the results obtained using these models,
- be able to use the models to analyze more complex data sets.

Content
This course covers basic models of statistics that allow us to capture relationships between variables. Topics include

- Linear regression models:
  Model diagnostics
  Multicollinearity
  Variable selection
  Generalized least squares
- Nonlinear regression models:
  Parameter estimation
  Asymptotic normality of maximum likelihood estimators
- Regression models for count data
- Generalized linear models:
  Parameter estimation
  Model diagnostics
  Overdispersion and quasi-likelihood

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures, problem classes, and examination

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations

The contents of the course "Statistics" are strongly recommended.

2.73 Module: Geometric Analysis [M-MATH-102923]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105892	Geometric Analysis	8 CP	Lamm

Prerequisites
none

2.74 Module: Geometric Group Theory [M-MATH-102867]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	see Annotations	1 term	4	1

Mandatory			
T-MATH-105842	Geometric Group Theory	8 CP	Herrlich, Link, Llosa Isenrich, Sauer, Tuschmann

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

2.75 Module: Geometric Group Theory II [M-MATH-102869]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105875	Geometric Group Theory II	8 CP	Herrlich, Llosa Isenrich, Sauer

Prerequisites
none

M 2.76 Module: Geometric Numerical Integration [M-MATH-102921]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105919	Geometric Numerical Integration	6 CP	Hochbruck, Jahnke

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
none

Competence Goal
After attending the course, students understand the central properties of finite-dimensional Hamilton systems (energy conservation, symplectic flow, first integrals etc.). They know important classes of geometric time integrators such as, e.g., symplectic (partitioned) Runge-Kutta methods, splitting methods, SHAKE and RATTLE. They are not only able to implement these methods and apply them to practice-oriented problems, but also to analyze and explain the observed long-time behavior (e.g. approximative energy conservation over long times).

Content

- Newtonian equation of motion, Lagrange equations, Hamilton systems
- Properties of Hamilton systems: symplectic flow, energy conservation, other conserved quantities
- Symplectic numerical methods: symplectic Euler method, Störmer-Verlet method, symplectic (partitioned) Runge-Kutta methods
- Construction of symplectic methods, for example by composition and splitting
- Backward error analysis and energy conservation over long time intervals
- Mechanical systems with constraints

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
The module is offered about every two years

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Familiarity with ordinary differential equations and Runge-Kutta methods (construction, order, stability, etc.) are strongly recommended. The course "Numerical methods for differential equations" provides an excellent basis. Moreover, programming skills in MATLAB are strongly recommended.

2.77 Module: Geometric Variational Problems [M-MATH-106667]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113418	Geometric Variational Problems	8 CP	Lamm

Assessment
oral exam of ca. 30 min

Prerequisites
none

Competence Goal
The students

- can name basic results in the theory of geometric variational problems and relate them to each other;
- are prepared to write a thesis in the field of geometric analysis.

Content

- Harmonic maps
- Willmore surfaces
- Regularity theory
- Hardy and BMO spaces

Module Grade Calculation
The module grade is the grade of the oral examination.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The modules *Classical Methods for Partial Differential Equations* and *Functional Analysis* are recommended.

M 2.78 Module: Geometry of Schemes [M-MATH-102866]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105841	Geometry of Schemes	8 CP	Herrlich, Kühnlein

Assessment
The modules is completed by an oral exam of about 30 minutes

Prerequisites
None

Competence Goal
At the end of the module, participants are able to

- relate the notion of algebraic schemes with that of algebraic varieties
- name and discuss basic properties of schemes
- deal with sheaves on schemes and investigate their properties
- start to read recent research papers in algebraic geometry and write a thesis in this field.

Content

- Sheaves of modules
- affine schemes
- varieties and schemes
- morphisms between schemes
- coherent and quasicoherent sheaves
- cohomology of sheaves

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total work load. 240 hours

Attendance: 90 hours

- lectures, problem classes and examination

Self studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature studies and internet research relating to the course content
- preparation for the module examination

Recommendations
The modules "Algebra" and "Algebraic Geometry" are strongly recommended.

2.79 Module: Global Differential Geometry [M-MATH-102912]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105885	Global Differential Geometry	8 CP	Tuschmann

Prerequisites
none

2.80 Module: Graph Theory [M-MATH-101336]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	English	4	3

Mandatory			
T-MATH-102273	Graph Theory	8 CP	Aksenovich

Assessment
The final grade is given based on the written final exam (3h).

By successfully working on the problem sets, a bonus can be obtained. To obtain the bonus, one has to achieve 50% of the points on the solutions of the exercise sheets 1-6 and also of the exercise sheets 7-12. If the grade in the final written exam is between 4,0 and 1,3, then the bonus improves the grade by one step (0,3 or 0,4).

Prerequisites
None

Competence Goal
The students understand, describe and use fundamental notions and techniques in graph theory. They can represent the appropriate mathematical questions in terms of graphs and use the results such as Menger's theorem, Kuratowski's theorem, Turan's theorem, as well as the developed proof ideas, to solve these problems. The students can analyze graphs in terms of their characteristics such as connectivity, planarity, and chromatic number. They are well positioned to understand graph theoretic methods and use them critically. Moreover, the students can communicate using English technical terminology.

Content
The course Graph Theory treats the fundamental properties of graphs, starting with basic ones introduced by Euler and including the modern results obtained in the last decade. The following topics are covered: structure of trees, paths, cycles and walks in graphs, minors, unavoidable subgraphs in dense graphs, planar graphs, graph coloring, Ramsey theory, and regularity in graphs.

Additional Information

- Course is held in English
- This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

2.81 Module: Group Actions in Riemannian Geometry [M-MATH-102954]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105925	Group Actions in Riemannian Geometry	5 CP	Tuschmann

Prerequisites
none

2.82 Module: Harmonic Analysis [M-MATH-105324]

Responsible: Prof. Dr. Dorothee Frey
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-111289	Harmonic Analysis	8 CP	Frey, Kunstmann, Schnaubelt, Tolksdorf

Content

- Fourier series
- Fourier transform on L1 and L2
- Tempered distributions and their Fourier transform
- Explizit solutions of the Heat-, Schrödinger- and Wave equation in Rn
- the Hilbert transform
- the interpolation theorem of Marcinkiewicz
- Singular integral operators
- the Fourier multiplier theorem of Mihlin

2.83 Module: Harmonic Analysis 2 [M-MATH-106486]

Responsible: Prof. Dr. Dorothee Frey
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113103	Harmonic Analysis 2	8 CP	Frey, Kunstmann, Tolksdorf

Assessment
Oral examination of ca. 30 minutes.

Prerequisites
None

Competence Goal
The students

- can explain basic results on Riesz tranforms and in the Littlewood-Paley theory.
- can explain the basic results on Hardy spaces and BMO and put them into context.
- can describe fundamental results on oscillatory integrals and apply them to examples.
- can describe fundamental results for the study of dispersive equations and discuss them.
- master important techniques of proofs for singular integral operators and oscillatory integrals and can sketch central proofs.
- are prepared to write a thesis in the field of Harmonic Analysis or dispersive equations.

Content

- Riesz transforms and related singular integral operators
- Littlewood-Paley theory
- Hardy space H^1 and the space BMO
- sharp maximal functions and good-lambda inequalities
- oscillatory integrals, dispersive estimates, Strichartz estimates
- applications to various differential equations

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The following modules are strongly recommended: "Harmonic Analysis", "Functional Analysis".

M 2.84 Module: Heat Transfer II [M-CIWVT-103051]

Responsible: Prof. Dr.-Ing. Thomas Wetzel
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	4

Mandatory			
T-CIWVT-106067	Heat Transfer II	6 CP	Wetzel

Assessment
The examination is an oral examination with a duration of 20 minutes (section 4 subsection 2 number 2 SPO).
Module grade is the grade of the oral examination.

Prerequisites
None

Competence Goal
Students can deduce the basic differential equations of thermofluiddynamics and know possible simplifications. They know different analytical and numerical solution methods for the transient temperature field equation in quiescent media and are able to use them actively. Students are able to apply these solution methods independently to other heat conduction problems such as the heat transfer in fins and needles.

Content
Advanced topics in heat transfer:

Thermo-fluid dynamic transport equations, transient heat conduction; thermal boundary conditions; analytical methods (combination and separation of variables, Laplace transform); numerical methods (finite difference and volume methods); heat transfer in fins and needles

Module Grade Calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 45 h
- Homework: 75 h
- Exam Preparation: 60 h

Literature

- Von Böckh/Wetzel: „Wärmeübertragung“, Springer, 6. Auflage 2015
- VDI-Wärmeatlas, Springer-VDI, 10. Auflage, 2011

M 2.85 Module: High Temperature Process Engineering [M-CIWVT-103075]

Responsible: Prof. Dr.-Ing. Dieter Stapf
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-CIWVT-106109	High Temperature Process Engineering	6 CP	Stapf

Assessment
The examination is an oral examination with a duration of about 20 minutes (section 4 subsection 2 number 2 SPO).

Prerequisites
None

Module Grade Calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 45 h
- Homework: 75 h
- Exam Preparation: 60 h

M 2.86 Module: Homotopy Theory [M-MATH-102959]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-105933	Homotopy Theory	8 CP	Sauer

M 2.87 Module: Infinite dimensional dynamical systems [M-MATH-103544]

Responsible: Prof. Dr. Jens Rottmann-Matthes
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-107070	Infinite dimensional dynamical systems	4 CP	Rottmann-Matthes

Prerequisites
None

M 2.88 Module: Information Security [M-INFO-106015]

Responsible: Prof. Dr. Hannes Hartenstein
Prof. Dr. Thorsten Strufe

Organisation: KIT Department of Informatics

Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
5 CP	graded	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-112195	Information Security	5 CP	Hartenstein, Strufe

M 2.89 Module: Integral Equations [M-MATH-102874]

Responsible: PD Dr. Frank Hettlich
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105834	Integral Equations	8 CP	Arens, Griesmaier, Hettlich

Assessment
The module will be completed by an oral exam (~30min.).

Prerequisites
none

Competence Goal
The students can clarify integral equations and can show existence and uniqueness of solutions by perturbation theory and by Fredholm theory. Ideas of proofs for Fredholm theory and perturbation theory especially in case of convolution equations can be described and explained. Furthermore, the students can formulate classical boundary value problems for ordinary differential equations and from potential theory in terms of integral equations.

Content

- Riesz and Fredholm theory
- Fredholm and Volterra integral equations
- Applications in potential theory
- convolution equation

Module Grade Calculation
The module grade is the the grade of the oral exam

Workload
Total workload: 240h

Attendance: 90h

- Lecture, problem class, examination

Self studies: 150h

- follow-up and deepening of the course content
- work on problem sheets
- literature studies and internet research related to the course content
- preparation of the module examination

2.90 Module: Integrated Photonics [M-ETIT-107344]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-114418	Integrated Photonics	6 CP	Koos

Assessment
The assessment takes place in the form of an oral examination (approx. 25 minutes); appointments individually on demand.

Prerequisites
none

Competence Goal
At the end of the course, students

- have a refreshed and deepened understanding of the basic principles of light-matter-interaction and wave propagation in dielectric media,
- know and understand the Lorentz model for frequency-dependent material properties and can use this knowledge to quantitatively analyze the dispersive properties of optical media using Sellmeier relations and scientific databases,
- understand and can quantitatively describe the formation and propagation of surface plasmon polaritons (SPP),
- know basic structures of integrated optical waveguides and understand the formation of guided modes in these structures,
- can quantitatively describe the propagation of signals in optical waveguides under the influence of dispersion,
- are familiar with state-of-the-art material systems and technology platforms of integrated photonics,
- understand basic analytical methods for modeling of photonic circuits such as eigenmode expansion (EME) methods, scattering-matrix formalisms, or coupled-mode theory and can apply these methods to specific use cases,
- understand the concepts and limitations of widely used computational techniques for integrated optical devices such as numerical mode solvers or finite-difference-time-domain (FDTD) simulators,
- know and can quantitatively analyze widely used building blocks and passive devices of integrated photonics, comprising, e.g., multi-mode interference (MMI) couplers, directional couplers, and waveguide gratings, as well as Mach-Zehnder interferometers (MZI), arrayed-waveguide gratings (AWG), lattice filters, and ring resonators.
- understand lasers and optical amplifiers and are familiar with the associated models, e.g., based on rate equations, and their predictions for dynamic behavior
- know material systems and device concepts used for electro-optic modulators
- understand photodetectors and the origin and quantitative description of noise in optoelectronic receiver systems.

Content

This course is geared towards engineering students that want to get a deeper insight into the vividly growing field of integrated photonics. The lecture and the associated tutorial provide an advanced understanding of the physical concepts and associated mathematical models of photonic integrated circuits, of the underlying material platforms and fabrication technologies, and of related application in optical communications, optical sensing, or microwave photonics. The concepts explained in the lecture are widely applicable also in fields outside integrated optics and can be a perfect complement to a variety of topics and adjacent fields such as communications engineering and high-speed data transmission, radio-frequency (RF) electronics, sensor system engineering and automation, photovoltaics, or quantum technologies.

The course covers the following aspects:

1. Review of fundamentals of wave propagation and light-matter interaction in photonics: Maxwell’s equations in optical media, wave equation and plane waves; material dispersion; Lorentz and Drude model of refractive index; Sellmeier equations
2. Plasmonics: Fundamentals of surface-plasmonic polariton (SPP) propagation
3. Integrated optical waveguides: Basic structures; formation of guided modes; mathematical description; orthogonality of modes
4. Propagation of optical signals in waveguides: Group velocity; dispersion; outlook to nonlinear optical effects
5. Optical fibers: Step-index fibers and associated modes; micro-structured fibers
6. Overview of material systems and integration platforms: Silicon photonics, silicon-nitride-based photonic circuits; III-V compound semiconductors; thin-film lithium niobate; polymer-based photonic circuits
7. Eigenmode expansion (EME) method: Concept and applications
8. Numerical methods in integrated photonics: Basics of numerical mode solvers and finite-difference-time-domain (FDTD) simulators
9. Scattering-matrices (S-matrices) for optical devices: Definition and properties of S-matrices
10. Coupled-mode theory and building blocks of integrated photonics: Multi-mode interference (MMI) devices; directional couplers; waveguide gratings
11. Selected passive devices: Mach-Zehnder interferometers (MZI); arrayed-waveguide gratings (AWG); lattice filters; ring resonators
12. Lasers and optical amplifiers: Material systems; quantitative model and rate equations; dynamic behaviour of lasers
13. Electro-optic modulators: Material systems, device concepts, and figures of merit
14. Photodetectors and noise in optoelectronic receiver systems: Photodetector concepts and implementations; direct and coherent detection; shot noise; thermal noise; noise figures

Module Grade Calculation

The module grade is the grade of the oral exam under consideration of any bonuses that may apply

The module grade is the grade of the oral exam under consideration of bonuses based on the problem sets that are solved during the term – details will be given during the lecture. A bonus of 0.3 or 0.4 grades will be granted on the final mark of the oral exam, except for grades worse than 4.0. Bonus points do not expire and are retained for any examinations taken at a later date.

Workload

The workload amounts to approximately 180 h (6 CP), comprising the following items:

Attendance of lectures and tutorials: 15 × (2 h +2 h) = 60 h
Preparation and follow-up of lectures: 15 × 3 h = 45 h
Preparation and follow-up of tutorials: 15 × 3 h = 45 h
Preparation of oral exam: 30 h

Recommendations

Basics understanding of the underlying topics such as electromagnetic fields and waves, semiconductors and solid-state electronics, and advanced calculus. These skills can, e.g., be acquired in the modules “Höhere Mathematik I-III”, “Elektromagnetische Felder und Wellen”, “Festkörperelektronik und Bauelemente“, and „Fundamentals of Photonics“ or in comparable lectures.

2.91 Module: Internet Seminar for Evolution Equations [M-MATH-102918]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	German/English	4	1

Mandatory			
T-MATH-105890	Internet Seminar for Evolution Equations	8 CP	Frey, Kunstmann, Schnaubelt, Tolksdorf

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
Students can explain the basic ideas, concepts and statements of a sub-area of the theory of evolutionary equations and apply them to examples. They can work on this topic from a script and discuss it in a reading course.

Content
A part of the theory of evolution equations is introduced. The necessary basics (beyond the contents of an introductory lecture in functional analysis) are developed. The basic concepts, statements and methods of the respective subarea are treated systematically. Applications of the theory are discussed.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
The internet seminar has different main organizers each year, who send out a manuscript with exercises and provide a website with discussion forums. In Karlsruhe, the material is discussed in a two-hour reading course in the winter semester, which is roughly equivalent to a four-hour lecture with exercises. There is the opportunity (outside of our modules) to work on a project during the summer semester and present it at a final workshop in June. Further information and details on the current content can be found on Roland Schnaubelt's website, http://www.math.kit.edu/iana3/~schnaubelt/en

Workload
Total workload: 240 hours

Attendance: 30 h

- lectures and examination

Self studies: 210 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the module "Functional Analysis" are strongly recommended.

2.92 Module: Internship [M-MATH-102861]

Responsible: Prof. Dr. Willy Dörfler
PD Dr. Markus Neher
Organisation: KIT Department of Mathematics
Part of: Internship

Credits	Grading	Recurrence	Duration	Level	Version
10 CP	pass/fail	Each term	1 term	4	1

Mandatory			
T-MATH-105888	Internship	10 CP	Dörfler, Neher

Workload
Gesamter Arbeitsaufwand: 300 Stunden.

Präsenzzeit: 270 Stunden im Unternehmen.

Selbststudium: 30 Stunden

- Ausarbeitung des Berichtes
- Vorbereitung und Halten der Präsentation

M 2.93 Module: Interpolation Spaces [M-MATH-107456]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-114639	Interpolation Spaces	6 CP	Kunstmann, Lamm

Assessment
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Prerequisites
none

Competence Goal
Graduates

- are able to state and discuss essential results on interpolation theory and maximum L^p regularity,
- can state and discuss basic results on Besov spaces and relate them to each other,
- can state basic results in the treatment of partial differential equations and relate them to each other,
- can outline central proofs,
- are prepared to write a thesis in the field of harmonic analysis or global analysis.

Content

- Real and complex interpolation,
- function spaces,
- maximal L^p regularity,
- applications to partial differential equations.

Module Grade Calculation
The module grade is the grade of the oral examination.

Workload
Attendance time: 60 hours

- Course including module examination during the course of study

Self-study: 120 hours

- Consolidation of the course content by working on the lecture content at home
- completion of exercises
- In-depth study of the course content using suitable literature and internet research
- Preparation for the module examination during the course of study

Recommendations
The modules 'Functional Analysis' and 'Classical Methods in PDE's' are strongly recommended.

2.94 Module: Introduction into Particulate Flows [M-MATH-102943]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	graded	Once	1 term	4	1

Mandatory			
T-MATH-105911	Introduction into Particulate Flows	3 CP	Dörfler

Prerequisites
none

M 2.95 Module: Introduction to Artificial Intelligence [M-INFO-106014]

Responsible: TT-Prof. Dr. Pascal Friederich
Prof. Dr. Gerhard Neumann

Organisation: KIT Department of Informatics

Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
5 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-112194	Introduction to Artificial Intelligence	5 CP	Friederich, Neumann

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module **M-INFO-100819 - Cognitive Systems** must not have been started.

2.96 Module: Introduction to Convex Integration [M-MATH-105964]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112119	Introduction to Convex Integration	3 CP	Zillinger

Assessment
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
The main aim of this lecture is to introduce students to convex integration as a tool to construct solutions to partial differential equations.
In particular, they will be able to

- discuss the structure of convex integration algorithms,
- state major theorems and their relation,
- discuss regularity of convex integration solutions and uniqueness,
- discuss building blocks of constructions and their properties.

Content
This lecture provides an introduction to the methods of convex integration and its applications:

- for isometric immersions,
- for the m-well problem in elasticity,
- for equations of fluid dynamics and
- higher regularity of convex integration solutions.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 h

- lectures and examination

Self studies: 60 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The modules "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

M 2.97 Module: Introduction to Cosmology [M-PHYS-102175]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102384	Introduction to Cosmology	6 CP	Drexlin

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Competence Goal
Students will be introduced to the basic concepts of cosmology. The lecture will provide both the theoretical concepts and an overview of modern experimental methods and observational techniques. The students will be enabled to understand the concepts by means of concrete case studies from modern cosmology and will be enabled to apply the learned methods in the context of later independent research.

Methodological Competency Acquisition:

- Understanding of the fundamentals of cosmology
- Recognition of methodological cross-connections to elementary particle physics and astroparticle physics.
- Acquisition of the ability to work independently on current research topics as preparation for the master thesis.

Content
The lecture offers an introduction to modern cosmology, which has taken an enormous upswing in recent years due to the use of state-of-the-art technologies (Planck satellite, galaxy surveys such as 2dF and SDSS) and accompanying computationally intensive simulations (Millennium). The large number of observations has led to the establishment of a so-called concordance model of cosmology, in which the contributions of dark energy and dark matter dominate the evolution of large-scale structures in the universe.

Starting from a description of the early universe with the supporting pillars of the Big Bang theory (Hubble expansion, nucleosynthesis, cosmic background radiation) and the phase transitions and symmetry breaking that occur in the process, the formation and evolution of large-scale structures in the universe up to today's "dark universe" is discussed (comparison of "top-down" with "bottom-up" models). Special attention is given to a detailed presentation of the most modern experimental techniques and methods of analysis, which have found their way into wide areas of physics.

The lecture thus provides a coherent picture of modern cosmology and discusses fundamental issues also in neighboring disciplines such as particle physics and astrophysics and can therefore be complemented with other lectures in the field of Experimental Astroparticle Physics and Experimental Particle Physics.

Workload
180 hours consisting of attendance time (45 hours), wrap-up of the lecture incl. exam preparation and preparation of the exercises (135 hours).

Recommendations
Basic knowledge from lecture "Nuclei and Particles

Literature
Will be mentioned in the lecture.

2.98 Module: Introduction to Dynamical Systems [M-MATH-106591]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113263	Introduction to Dynamical Systems	6 CP	de Rijk, Reichel

Assessment
The module will be completed with an oral exam of about 30 minutes.

Prerequisites
None

Competence Goal
After successful completion of this module students

- can explain the significance of dynamical systems and give several examples;
- have acquired miscellaneous tools to prove the existence of special solutions and to analyze the local dynamics around them;
- master several techniques to describe global dynamics in certain classes of dynamical systems;
- identify various bifurcations and explain how these change the dynamics of the system;
- outline the main steps in establishing chaotic behavior.

Content

- Flows
- Abstract dynamical systems
- Lyapunov functions
- Invariant sets
- Limit sets and attractors
- Hartman-Grobman theorem
- Local (un)stable manifold theorem
- Poincaré-Bendixson theorem
- Periodic orbits and Floquet theory
- Exponential dichotomies
- Melnikov functions
- Lin's method
- Hamiltonian dynamics
- Liénard systems
- Bifurcations
- Chaotic dynamics
- (Introduction to) Fenichel theory
- Center manifolds
- Dynamical systems associated with semilinear evolution equations

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The following modules are strongly recommended: Analysis 1-2 and Linear Algebra 1-2. The module Analysis 4 is recommended.

M 2.99 Module: Introduction to Fluid Dynamics [M-MATH-105650]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-111297	Introduction to Fluid Dynamics	3 CP	Reichel

Assessment
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
None

Competence Goal
The main aim of this lecture is to introduce students to mathematical fluid dynamics. In particular, by the end of the course students will be able to

- discuss and explain the various formulations of the Euler equations and when these formulations are equivalent,
- state major theorems and their relation,
- discuss weak formulations, existence and uniqueness results.

Content
Mathematical description and analysis of fluid dynamics:

- physical motivation of the incompressible Euler and Navier-Stokes equations,
- Vorticity-Stream formulation and Eulerian and Lagrangian coordinates,
- Local existence theory and energy methods,
- Weak solutions and the Beale-Kato-Majda criterion.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the courses "Classical Methods for Partial Differential Equations" or "Boundary and Eigenvalue Problems" are recommended.

M 2.100 Module: Introduction to Fluid Mechanics [M-MATH-106401]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112927	Introduction to Fluid Mechanics	6 CP	Liao

Assessment
The module examination takes the form of an oral examination of approx. 25 minutes.

Prerequisites
None

Competence Goal
Graduates can

- recognize the essential formulations of the partial differential equations in fluid mechanics and explain them using examples,
- use techniques to describe the weak and strong solutions for the Euler and Navier-Stokes equations, and show the existence, uniqueness and regularity results,
- name the special difficulties in the three-dimensional case,
- understand the concept of stratification and explain it using concrete examples.

Content

- Derivation of models, modeling
- Euler equations, Navier-Stokes equations
- Biot-Savart law, Leray-Hopf decomposition
- Wellposedness results
- Regularity results

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
total work load: 180 hours

Recommendations
The module *Functional Analysis* is strongly recommended.

2.101 Module: Introduction to Geometric Measure Theory [M-MATH-102949]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105918	Introduction to Geometric Measure Theory	6 CP	Winter

Prerequisites
none

2.102 Module: Introduction to Homogeneous Dynamics [M-MATH-105101]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-110323	Introduction to Homogeneous Dynamics	6 CP	Hartnick

Prerequisites
None

M 2.103 Module: Introduction to Kinetic Equations [M-MATH-105837]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-MATH-111721	Introduction to Kinetic Equations	3 CP	Zillinger

Assessment
oral examination of approx. 30 minutes

Prerequisites
none

Competence Goal
The main aim of this lecture is to introduce students to the theory of kinetic transport equations. In particular, by the end of the course students will be able to

- discuss properties of the free transport, Boltzmann and Vlasov-Poisson equations,
- state major theorems and their relation,
- discuss notions of solutions and their properties,
- discuss the effects of phase mixing and challenges of nonlinear equations.

Content
Mathematical description and analysis of kinetic transport equations:

- the free transport, Boltzmann and Vlasov-Poisson equations,
- linear theory, phase mixing and Landau damping,
- equilibrium solutions and stability,
- nonlinear results and methods,
- renormalized solutions.

Module Grade Calculation
The module grade is the grade of the final oral exam.

Workload
Totel workload: 90 h

Attendance: 30 h

- lectures and examination

Self studies: 60 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the course "Classical Methods for Partial Differential Equations" are recommended.

M 2.104 Module: Introduction to Kinetic Theory [M-MATH-103919]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-MATH-108013	Introduction to Kinetic Theory	4 CP	Frank

Prerequisites
None

Competence Goal
After successfully taking part in the module’s classes and exams, students have gained knowledge and abilities as described in the “Inhalt” section. Specifically, Students know common means of mesoscopic and macroscopic description of particle systems. Furthermore, students are able to describe the basics of multiscale methods, such as the asypmtotic analysis and the method of moments. Students are able to apply numerical methods to solve engineering problems related to particle systems. They can name the assumptions that are needed to be made in the process. Students can judge whether specific models are applicable to the specific problem and discuss their results with specialists and colleagues.

Content

- From Newton's equations to Boltzmann's equation
- Rigorous derivation of the linear Boltzmann equation
- Properties of kinetic equations (existence & uniqueness, H theorem)
- The diffusion limit
- From Boltzmann to Euler & Navier-Stokes
- Method of Moments
- Closure techniques
- Selected numerical methods

Recommendations
Partial Differential Equations, Functional Analysis

M 2.105 Module: Introduction to Microlocal Analysis [M-MATH-105838]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111722	Introduction to Microlocal Analysis	3 CP	Liao

Assessment
oral examination of circa 30 minutes

Prerequisites
none

Competence Goal

- Students will become familiar with the notions of Fourier multipliers and pseudo-differential operators
- Students can state major theorems and their relation
- Students will understand the structure of the propagation of singularities by introducing the wave front set and apply them to the domain of partial differential equations, control theory, etc.

Content

1. Pseudo-differential operators
2. Symbolic calculus
3. Wavefront set
4. Propagation of singularities
5. Microlocal defective measure

Module Grade Calculation
The module grade is the grade of the final oral exam.

Workload
Totel workload: 90 h

Attendance: 30 h

- lectures and examination

Self studies: 60 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The following courses should be studied beforehand: "Classical Methods for Partial Differential Equations" und "Functional Analysis".

2.106 Module: Introduction to Scientific Computing [M-MATH-102889]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Tobias Jahnke

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each summer term	1 term	4	3

Mandatory			
T-MATH-105837	Introduction to Scientific Computing	8 CP	Dörfler, Hochbruck, Jahnke, Rieder, Wieners
T-MATH-114059	Project Lab Scientific Computing	0 CP	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

Assessment
The module will be completed by an oral exam (about 30 min).

Requirement for exam: Successful Hands-on tutorial

Prerequisites
None

Competence Goal
At the end of the course, students

- are able to develop the interlinking of all aspects of scientific computing using simple examples: from modeling and algorithmic implementation to stability and error analysis.
- can explain concepts of modeling with differential equations
- are able to implement simple application examples algorithmically, evaluate the code and present and discuss the results.

Content

- Numerical methods for initial value problems, boundary value problems, and initial boundary value problems
- Modelling with differential equations
- Algorithmic realization of applications
- Presentation of results of scientific computations

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
3 SWS lecture plus 3 SWS hands-on training

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets and coding,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
It is strongly recommended that participants have completed the modules "Numerische Mathematik 1 und 2" as well as "Programmieren: Einstieg in die Informatik und algorithmische Mathematik".

M 2.107 Module: Introduction to Stochastic Differential Equations [M-MATH-106045]

Responsible: Prof. Dr. Mathias Trabs
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112234	Introduction to Stochastic Differential Equations	4 CP	Janák, Trabs

Assessment
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
The students will

- know fundamental examples for linear and non-linear stochastic differential equations,
- be able to apply basic solution concepts for stochastic differential equations,
- know fundamental theorems of stochastic calculus and will be able to apply these to stochastic differential equations.

Content

1. Introduction and recapitulation of stochastic integration, Itô's formula, Lévy Theorem
2. Burkholder-Davis-Gundy inequality
3. Existence and uniqueness of solutions of stochastic differential equations
4. Explicit solutions of linear stochastic differential equations
5. Change of the time scale of Brownian motion
6. Representation of continuous time martingales
7. Brownian martingales
8. Local and global solutions of stochastic differential equations
9. Girsanov Theorem

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures, problem classes, and examination

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the course "Probability Theory" are strongly recommended. The contents of the course "Continuous Time Finance" are recommended.

M 2.108 Module: Inverse Problems [M-MATH-102890]

Responsible: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	1

Mandatory			
T-MATH-105835	Inverse Problems	8 CP	Arens, Griesmaier, Hettlich, Rieder

Assessment
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
None

Competence Goal
At the end of the course, students are able to distinguish well-posed from ill-posed problems. They acquire a systematic knowledge of the theory of linear inverse problems and their regularization in Hilbert spaces and can provide proof ideas. They are able to analyze regularization methods such as, e.g., Tikhonov regularization and assess their convergence properties.

Content

- Compact operator equations
- Ill-posed problems
- Regularization
- Tikhonov regularization
- Iterative regularization
- Examples for ill-posed problems

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course "Functional Analysis" or "Integral Equations" is recommended as a prerequisite.

2.109 Module: IT Security [M-INFO-106998]

Responsible: Prof. Dr. Jörn Müller-Quade
Prof. Dr. Christian Wressnegger
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-INFO-113960	IT Security	6 CP	Müller-Quade, Wressnegger

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students
• have in-depth knowledge of cryptography and IT security
• know and understands sophisticated techniques and security primitives to achieve the protection goals
• know and understand scientific evaluation and analysis methods of IT security (game-based formalization of confidentiality and integrity, security and anonymity notions)
• have a good understanding of types of data, personal data, legal and technical fundamentals of privacy protection
• know and understand the fundamentals of system security (buffer overflow, return-oriented programming, ...)
• know different mechanisms for anonymous communication (TOR, Nym, ANON) and can assess their effectivity

Content
This advanced mandatory module deepens different topics of IT security. These include in particular:
• Elliptic curve cryptography
• Threshold cryptography
• Zero-knowledge proofs
• Secret sharing
• Secure multi-party computation and homomorphic encryption
• Methods of IT security (game-based analysis and the UC model)
• Crypto-currencies and consensus through proof-of-work/stake
• Anonymity on the Internet, anonymity with online payments
• Privacy-preserving machine learning
• Security of machine learning
• System security and exploits
• Threat modeling and quantification of IT security

Workload
Course workload:
1. Attendance time: 56 h
2. Self-study: 56 h
3. Preparation for the exam: 68 h

Recommendations
Attendance of the lecture Information Security is recommended.

Literature
Literature:
• Katz/Lindell: Introduction to Modern Cryptography (Chapman & Hall)
• Schäfer/Roßberg: Netzsicherheit (dpunkt)
• Anderson: Security Engineering (Wiley, and online)
• Stallings/Brown: Computer Security (Pearson)
• Pfleeger, Pfleeger, Margulies: Security in Computing (Prentice Hall)

M 2.110 Module: Key Competences [M-MATH-102994]

Organisation: KIT Department of Mathematics
Part of: Interdisciplinary Qualifications

Credits	Grading	Recurrence	Duration	Language	Level	Version
2 CP	pass/fail	Each term	1 term	German	4	4

Election Notes
For self-assessment of interdisciplinary qualifications from HoC, FORUM or SPZ, the components with the title "Selbstverbuchung-HOC-SPZ-FORUM-..." must be selected according to the grading scale, ungraded or graded.

Key Competences (Election: at least 2 credits)			
T-MATH-106119	Introduction to Python	4 CP	Weiß
T-MATH-111515	Self-Booking-HOC-SPZ-FORUM-1-Graded	2 CP	
T-MATH-111517	Self-Booking-HOC-SPZ-FORUM-2-Graded	2 CP	
T-MATH-111516	Self-Booking-HOC-SPZ-FORUM-5-Ungraded	2 CP	
T-MATH-111520	Self-Booking-HOC-SPZ-FORUM-6-Ungraded	2 CP	
T-MATH-112651	Self-Booking-HOC-SPZ-FORUM-PEBA-9-Graded	2 CP	
T-MATH-112652	Self-Booking-HOC-SPZ-FORUM-PEBA-10-Ungraded	2 CP	

Prerequisites
None

M 2.111 Module: Lie Groups and Lie Algebras [M-MATH-104261]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German	4	1

Mandatory			
T-MATH-108799	Lie Groups and Lie Algebras	8 CP	Hartnick

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

M 2.112 Module: Lie-Algebras [M-MATH-106950]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German	4	1

Mandatory			
T-MATH-113907	Lie-Algebras	8 CP	Hartnick

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

2.113 Module: Localization of Mobile Agents [M-INFO-100840]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-101377	Localization of Mobile Agents	6 CP	Hanebeck
T-INFO-114169	Localization of Mobile Agents Pass	0 CP	Hanebeck

M 2.114 Module: Logical Foundations of Cyber-Physical Systems [M-INFO-106102]

Responsible: Prof. Dr. André Platzer
Organisation: KIT Department of Informatics
Part of: Computer Science
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	3

Mandatory			
T-INFO-112360	Logical Foundations of Cyber-Physical Systems	6 CP	Platzer

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
In modeling and control, successful students will
– understand core principles behind CPS. A solid understanding of these principles is important for anyone who wants to integrate cyber and physical components to solve problems that no part could solve alone.
– develop models and controls. In order to understand, design, and analyze CPS, it is important to be able to develop models for the relevant aspects of a CPS design and to design controllers for the intended functionalities based on appropriate specifications, including modeling with differential equations.
– identify relevant dynamical aspects. It is important to be able to identify which types of phenomena influence a property of a system. These allow us to judge, for example, where it is important to manage adversarial effects, or where a nondeterministic model is sufficient.

In computational thinking, successful students should be able to
– identify safety specifications and critical properties. In order to develop correct CPS designs, it is important to identify what “correctness” means, how a design may fail to be correct, and how to make it correct.
– understand abstraction in system designs. The power of abstraction is essential for the modular organization of CPS, and the ability to reason about separate parts of a system independently.
– express pre- and post-conditions and invariants for CPS models. Pre- and post-conditions allow us to capture under which circumstance it is safe to run a CPS or a part of a CPS design, and what safety entails. They allow us to achieve what abstraction and hierarchies achieve at the system level: decompose correctness of a full CPS into correctness of smaller pieces. Invariants achieve a similar decomposition by establishing which relations of variables remain true no matter how long and how often the CPS runs.
– reason rigorously about CPS models. Reasoning is required to ensure correctness and find flaws in CPS designs. Both informal and formal reasoning in a logic are important objectives for being able to establish correctness, which includes rigorous reasoning about differential equations.

In CPS skills, successful students will be able to
– understand the semantics of a CPS model. What may be easy in a classical isolated program becomes very demanding when that program interfaces with effects in the physical world.
– develop an intuition for operational effects. Intuition for the joint operational effect of a CPS is crucial, e.g., about what the effect of a particular discrete computer control algorithm on a continuous plant will be.
– understand opportunities and challenges in CPS and verification. While the beneficial prospects of CPS for society are substantial, it is crucial to also develop an understanding of their inherent challenges and of approaches for minimizing the impact of potential safety hazards. Likewise, it is important to understand the ways in which formal verification can best help improve the safety of system designs.

Content

Cyber-physical systems (CPSs) combine cyber capabilities (computation and/or communication) with physical capabilities (motion or other physical processes). Cars, aircraft, and robots are prime examples, because they move physically in space in a way that is determined by discrete computerized control algorithms. Designing these algorithms to control CPSs is challenging due to their tight coupling with physical behavior. At the same time, it is vital that these algorithms be correct, since we rely on CPSs for safety-critical tasks like keeping aircraft from colliding. In this course we will strive to answer the fundamental question posed by Jeannette Wing:

“How can we provide people with cyber-physical systems they can bet their lives on?”

The cornerstone of this course design are hybrid programs (HPs), which capture relevant dynamical aspects of CPSs in a simple programming language with a simple semantics. One important aspect of HPs is that they directly allow the programmer to refer to real-valued variables representing real quantities and specify their dynamics as part of the HP.

This course will give you the required skills to formally analyze the CPSs that are all around us—from power plants to pacemakers and everything in between—so that when you contribute to the design of a CPS, you are able to understand important safety-critical aspects and feel confident designing and analyzing system models. It will provide an excellent foundation for students who seek industry positions and for students interested in pursuing research.

Additional Information

Course web page: https://lfcps.org/course/lfcps.html

Workload

6 ECTS from 180h of coursework consisting of
45h = 15 * 3 from 3 SWS lectures
15h = 15 * 1 from 1 SWS exercises
68h preparation, reading textbook, studying
40h solving exercises
12h exam preparation

Recommendations

The course assumes prior exposure to basic computer programming and mathematical reasoning. This course covers the basic required mathematical and logical background of cyber-physical systems. You will be expected to follow the textbook as needed: André Platzer. Logical Foundations of Cyber-Physical Systems. Springer 2018. DOI:10.1007/978-3-319-63588-0

2.115 Module: Markov Decision Processes [M-MATH-102907]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105921	Markov Decision Processes	5 CP	Bäuerle

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
none

Competence Goal
At the end of the course, students

- can name the mathematical foundations of Markov Decision Processes and apply solution algorithm,
- can formulate stochastic, dynamic optimization problems as Markov Decision Processes,
- are able to work in a self-organized and reflective manner.

Content

- MDPs with finite time horizon
  - Bellman equation
  - Problems with structure
  - Applications
- MDPs with infinite time horizon
  - contracting MDPs
  - positive MDPs
  - Howards policy improvement
  - Solution by linear programs
- Stopping problems
  - finite and infinite time horizon
  - One-step-look-ahead rule

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 150 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course 'Probability theory' is strongly recommended and 'Markov chains' is recommended.

M 2.116 Module: Master's Thesis [M-MATH-102917]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Master's Thesis

Credits	Grading	Recurrence	Duration	Level	Version
30 CP	graded	Each term	1 term	4	1

Mandatory			
T-MATH-105878	Master's Thesis	30 CP	Kühnlein

Assessment
The Master's Thesis is graded according to the regulations from §14 (7) of Studien- und Prüfungsordnung. The handling time is six months. On submission of the Master's Thesis, according to §14 (5) the students have to confirm, that the thesis has been written independently without using undisclosed sources and tools, that passages which have been copied literally or in content have clearly been marked as such, and that the by-laws to implement scientific integrity at KIT in the recent version have been taken into account. If this confirmation is not contained, the thesis gets rejected. In case of a wrong confirmation, the thesis is graded with "not sufficient" (5.0). The thesis may be written in English.

If the thesis is planned to be written outside the KIT-department of mathematics, the approval by the examination board is required.

Further details are regulated by §14 of Studien- und Prüfungsordnung.

Prerequisites
For admission to the module Master's Thesis it is required that the student has successfully accomplished module examinations of at least 70 credit points.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. You need to have earned at least 70 credits in the following fields:
   - Wildcard Technical Field
   - Applied Mathematics
   - Internship
   - Chemical and Process Engineering
   - Electrical Engineering / Information Technology
   - Experimental Physics
   - Computer Science
   - Mathematical Specialization
   - Interdisciplinary Qualifications

Competence Goal
The students are able to work on a given topic independently and in a limited time, using scientific methods from the state of the art. They master the necessary scientific methods and techniques, modify them if necessary and develop them further if required. Alternative approaches are compared critically. In their thesis, the students write up their results clearly structured and in a way adequate to academic standards.

Content
Following §14 SPO the thesis should demonstrate that the students are able to work on a given topic from their course of studies independently and in a bounded time, using scientific methods from the state of the art. The students should have the opportunity to make suggestions for their topic. If the student petitions, in exceptional cases the head of the examination board takes care that the student receives a topic for a master thesis within four weeks. In that case, the topic is given by the head of the examination board. Further details are regulated by §14 of Studien- und Prüfungsordnung.

Workload
Total work load: 900 hours

Attendance: 0 hours

Self studies: 900 hours

2.117 Module: Mathematical Methods in Signal and Image Processing [M-MATH-102897]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105862	Mathematical Methods in Signal and Image Processing	8 CP	Rieder

Assessment
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Prerequisites
none

Competence Goal
Graduates know the essential mathematical tools of signal and image processing and their properties. They are able to apply these tools appropriately and to scrutinize and evaluate the results obtained.

Content

- Digital and analog systems
- Integral Fourier transform
- Sampling and resolution
- Discrete and fast Fourier transform
- Non-uniform sampling
- Anisotropic diffusion filters
- Variational methods

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course "Functional analysis" is recommended.

2.118 Module: Mathematical Methods of Imaging [M-MATH-103260]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-106488	Mathematical Methods of Imaging	5 CP	Rieder

Assessment
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
Graduates become familiar with some imaging methods and are able to discuss and analyze the underlying mathematical aspects. In particular, they will be able to explain the functional-analytical properties of the imaging operators. They can implement the corresponding reconstruction algorithms and they can explain and evaluate the artifacts that appear. They are able to apply the techniques they have learned to related problems.

Content

- Variants of tomography (X-ray, impedance, seismic, etc.)
- Properties of (generalized) Radon transforms
- Microlocal analysis/Pseudodifferential operators
- Ill-Posedness and regularization
- Reconstruction algorithms

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total work load: 150 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course „Functional Analysis“ is recommended.

M 2.119 Module: Mathematical Modelling and Simulation in Practise [M-MATH-102929]

Responsible: PD Dr. Gudrun Thäter
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-MATH-105889	Mathematical Modelling and Simulation in Practise	4 CP	Thäter

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
The general aim of this lecture course is threefold:

1) to interconnect different mathematical fields,
2) to connect mathematics and real life problems,
3) to learn to be critical and to ask relevant questions.

At the end of the course, students can

- work Project-orientated,
- link knowledge from different fields,
- develop typical modelling approaches on their own.

Content
Mathematical thinking (as modelling) and mathematical techniques (as tools) meet application problems such as:

- Differential equations
- Population models
- Traffic flow
- Game theory
- Chaos
- Mechanics and fluids

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
The lecture is always in English.

To earn the credits you have to attend the lecture, finish the work on one project during the term in a group of 2-3 persons and pass the exam. The topic of the project is up to the choice of each group.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures, problem classes, and examination
- Project presentations

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination,
- work on the project

Recommendations
Some basic knowledge of numerical mathematics is recommended.

Literature
Hans-Joachim Bungartz e.a.: Modeling and Simulation: An Application-Oriented Introduction, Springer, 2013

M 2.120 Module: Mathematical Statistics [M-MATH-102909]

Responsible: PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	2

Mandatory			
T-MATH-105872	Mathematical Statistics	8 CP	Ebner, Fasen-Hartmann, Klar, Trabs

Assessment
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
By the end of the course, students will

- know the basic concepts of mathematical statistics,
- be able to apply them independently to simple problems and examples,
- know specific probabilistic techniques and be able to use them for the mathematical analysis of estimation and test procedures,
- know the asymptotic behavior of maximum likelihood estimators and the generalized likelihood ratio for parametric test problems.

Content
The course covers basic concepts of mathematical statistics, in particular the finite optimality theory of estimators and tests, and the asymptotic behavior of estimators and test statistics. Topics are:

- Optimal and best linear unbiased estimators,
- Cramér-Rao bound in exponential families,
- sufficiency, completeness and the Lehmann-Scheffé theorem,
- the multivariate normal distribution,
- convergence in distribution and multivariate central limit theorem,
- Glivenko-Cantelli theorem,
- limit theorems for U-statistics,
- asymptotic estimation theory (maximum likelihood estimator),
- asymptotic relative efficiency of estimators,
- Neyman-Pearson tests and optimal unbiased tests,
- asymptotic tests in parametric models (likelihood ratio tests).

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the courses "Probability theory" and "Statistics" are strongly recommended.

M 2.121 Module: Mathematical Topics in Kinetic Theory [M-MATH-104059]

Responsible: Prof. Dr. Dirk Hundertmark
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-108403	Mathematical Topics in Kinetic Theory	4 CP	Hundertmark

Prerequisites
None

Competence Goal
The students are familiar with the basic questions in kinetic theory and methodical approaches to their solutions. With the acquired knowledge they are able to understand the required analytical methods and are able to apply them to the basic equations in kinetic theory.

Content

- Boltzmann equation: Cauchy problem and properties of solutions
- entropy and H theorem
- equilibrium and convergence to equilibrium
- other models of kinetic theory

2.122 Module: Maxwell's Equations [M-MATH-102885]

Responsible: PD Dr. Frank Hettlich
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105856	Maxwell's Equations	8 CP	Arens, Griesmaier, Hettlich

Assessment
The module will be completed by an oral exam (~30min.).

Prerequisites
none

Competence Goal
The students can explain mathematical questions from the theory of Maxwell's equations. They can formulate and prove the main theorems on properties and existence of solutions, can apply these to specific cases, and can compare results with simpler differential equations (like the Helmholtz equation).

Content
Specific examples of solutions to Maxwell's equations, properties of solutions (e.g. representation theorems), specific cases like E-mode and H-mode, corresponding boundary value problems.

Module Grade Calculation
The module grade is the grade of the oral exam

Workload
Total workload: 240h

Attendace: 90h

- lecture, problem class, examination

Self-studies: 150h

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation of the course content

Recommendations
Desirable is basic knowledge from functional analysis

M 2.123 Module: Medical Imaging Technology [M-ETIT-106778]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113625	Medical Imaging Technology	6 CP	Spadea

Assessment
The examination takes place in form of a written examination lasting 120 minutes.

Prerequisites
none

Competence Goal
For each imaging modality students will be able to:

- identify required energy source;
- analyze the interactions between the form of energy and biological tissue distinguishing desired signal from noise contribution;
- critically interpret the image content to derive knowledge
- evaluate image quality and implementing strategies to improve it.

Moreover, the students will be able to communicate in technical and clinical English languange.

Content

- Basic knowledge of mathematical and physical principles of medical imaging formation, including X-ray based modalities, nuclear medicine imaging, magnetic resonance imaging and ultrasound
- Components of medical imaging devices.
- Assessment of image quality in terms of signal-to-noise-ratio, presence of artifact, spatial, Spectral and temporal resolution
- Safety and protection for patients and workers.

Module Grade Calculation
The module grade is the grade of the written exam.

A bonus can be earned for voluntary tasks such as:

- presentation and discussion of a specific topic,
- participation to writing the lecture minutes
- implementation of educational tools

The exact criteria for awarding a bonus will be announced at the beginning of the lecture period. If the grade in the oral exam is between 4.0 and 1.3, the bonus improves the grade by 0.3 or 0.4.

Bonus points do not expire and are retained for any examinations taken at a later date.

Workload

1. attendance in lectures an exercises: 15*4 h = 60 h
2. preparation / follow-up: 15*6 h = 90 h
3. preparation of and attendance in examination: 30 h

A total of 180 h = 6 CR

Recommendations
Basic knowledge in the field of physics and signal processing is helpful.

2.124 Module: Metric Geometry [M-MATH-105931]

Responsible: Prof. Dr. Alexander Lytchak
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German	4	1

Mandatory			
T-MATH-111933	Metric Geometry	8 CP	Lytchak, Nepechiy

Assessment
oral examination of circa 20 minutes

Prerequisites
None

Module Grade Calculation
The module grade is the grade of the final oral exam.

Additional Information
This course is one of the nine core courses in the subject area Algebra and Geometry, from which at least six courses are offered within every two years (at least four different ones).

M 2.125 Module: Minimal Surfaces [M-MATH-106666]

Responsible: Dr. Peter Lewintan
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113417	Minimal Surfaces	3 CP	Lewintan

Assessment
The module will be completed by an oral exam (about 30 min).

Prerequisites
None

Competence Goal
Graduates

- are able to mathematically understand and solve a practical problem;
- can explain important results of the theory of minimal surfaces and apply them to examples;
- are prepared to write a thesis in the field of the theory of minimal surfaces or the calculus of variations.

Content
Minimal surfaces are critical points of the area functional and locally minimize its area. They can also be described by having zero mean curvature. In this course we consider two dimensional minimal surfaces in R^3 and discuss their properties. We will use arguments from differential geometry, the calculus of variations, the theory of partial differential equations and functions of a complex variable. Our goal is to prove the classical Plateau's problem.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course "Classical Methods for Partial Differential Equations" is recommended.

2.126 Module: Modelling and Simulation of Lithium-Ion Batteries [M-MATH-106640]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113382	Modelling and Simulation of Lithium-Ion Batteries	4 CP	Dörfler

Assessment
oral exam of ca. 20 minutes

Prerequisites
None

Competence Goal
Participants know about the modelling and physical basics that lead to the model equations. They can explain (at least for simplified problems) their well-posedness. They are able to analyze stability and convergence of the presented methods.

Content

- Derivation of the model equations,
- Existence for simplified model problems,
- Discretization of the initial boundary value problems with fiite elements,
- Nonlinear diffusion equations, Cahn-Hilliard equation, linear elasticity and contact problems,
- Stability and convergence of the discrete models,
- Applications

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 h

- lectures, problem classes and examination

Self studies: 75 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
Basic knowledge in the numerical treatment of differential equations, such as boundary value problems or initial value problems is strongly recommended.

M 2.127 Module: Models of Mathematical Physics [M-MATH-102875]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105846	Models of Mathematical Physics	8 CP	Hundertmark, Plum, Reichel

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- understand the modeling of fundamental physical effects,
- understand the most important mathematical properties of these differential equation models,
- calculate exemplary solutions,
- draw conclusions regarding the models from the provable properties of the differential equations and the solutions.

Content

- Reaction-diffusion models
- Wave phenomena
- Maxwell equations and electrodynamics
- Schrödinger equation and quantum mechanics
- Navier-Stokes equation and fluid dynamics
- Elasticity
- Surface tension

Module Grade Calculation
The module grade is the grade of the oral/written exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

2.128 Module: Modern Experimental Physics I, Atoms, Nuclei and Molecules [M-PHYS-106331]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-PHYS-112846	Modern Experimental Physics I, Atoms, Nuclei and Molecules	8 CP	Studiendekan Physik

Assessment
See components of this module

Prerequisites
none

M 2.129 Module: Modern Experimental Physics II, Structure of Matter [M-PHYS-106332]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-PHYS-112847	Modern Experimental Physics II, Structure of Matter	8 CP	Studiendekan Physik

Assessment
See components of this module

Prerequisites
none

M 2.130 Module: Modern Methods in Combinatorics [M-MATH-106957]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113911	Modern Methods in Combinatorics	6 CP	Aksenovich

Assessment
The module examination takes the form of an oral examination (approx. 30 min).

Prerequisites
None

Competence Goal
The students understand and are able to use powerful modern methods in Combinatorics.

Content
The course is concerned with modern methods in Combinatorics including probabilistic or algebraic ones. Every presented method is illustrated with several applications.

The probabilistic part includes the following topics: random graphs, linearity of expectation, second moment method, and Lovasz Local Lemma. The algebraic part includes: polynomial methods, spectral methods, and linear algebraic techniques.

Module Grade Calculation
The module grade is the grade of the oral examination.

Workload
Total workload: 180 hours

Attendance time: 60 hours

- Course including module examination during the course of study

Self-study: 120 hours

- Deepening the study content by working on the lecture content at home
- completion of exercises
- In-depth study of the course content using suitable literature and internet research
- Preparation for the module examination during the course of study

Recommendations
Some knowledge of linear algebra and probability theory is strongly recommended. The courses *Graph Theory* and *Combinatorics* are recommended but not required.

M 2.131 Module: Modular Forms [M-MATH-102868]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105843	Modular Forms	8 CP	Kühnlein

Assessment
The exam is an oral exam of about 30 minutes.

Prerequisites
None

Competence Goal
Participants are able to

- understand basic questions discussed in the theory of modular forms
- see the relevance of analytic results for solving certain arithmetic problems
- start reading a recent research paper and write a thesis in the area of modular forms.

Content

- Modular Group: Upper half plane, Mobius transforms, fundamental regions, Eisenstein series, modular forms, dimension formula
- congruence subgroups: Petersson scalar product, Hecke operators, Atkin-Lehner-theory of new forms
- L-series: Mellin transform, functional equation, Euler product decomposition of the L-series of a Hecke-eigenform

Module Grade Calculation
Grade of the oral exam

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classe and examination

Self studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research on the course content
- preparation for the module examination

Recommendations
The basic notions of algebra and number theory should be well-understood, and also basic principles of complex analysis.

M 2.132 Module: Monotonicity Methods in Analysis [M-MATH-102887]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105877	Monotonicity Methods in Analysis	3 CP	Herzog

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
None

Competence Goal
At the end of the course, students can

- name, discuss and apply basic techniques of the order-theoretical methods of analysis,
- apply specific order theory techniques to fixed point problems and differential equations.

Content

- Fixed point theorems in ordered sets and ordered metric spaces.
- Ordered Banach spaces.
- Quasimonotone increasing functions.
- Differential equations and differential inequalities in ordered Banach spaces.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course "Functional Analysis" is recommended.

M 2.133 Module: Multigrid and Domain Decomposition Methods [M-MATH-102898]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Once	1 term	4	1

Mandatory			
T-MATH-105863	Multigrid and Domain Decomposition Methods	4 CP	Wieners

Prerequisites
none

Competence Goal
The students became acquainted with multigrid and domain decomposition methods. They learn algorithms, results on convergence, and representative applications.

Content

- The two-grid method
- Classical multigrid theory
- Additive subspace correction method
- Multiplicative subspace correction method
- Multigrid methods for saddle point problems

M 2.134 Module: Neural Networks [M-INFO-100846]

Responsible: Prof. Dr. Alexander Waibel
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-101383	Neural Networks	6 CP	Waibel

M 2.135 Module: Nonlinear Analysis [M-MATH-103539]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-107065	Nonlinear Analysis	8 CP	Lamm

Prerequisites
None

M 2.136 Module: Nonlinear Control Systems [M-ETIT-100371]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100980	Nonlinear Control Systems	3 CP	Kluwe

Prerequisites
none

2.137 Module: Nonlinear Evolution Equations [M-MATH-102877]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-105848	Nonlinear Evolution Equations	8 CP	Frey, Schnaubelt

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Students can explain the well-posedness theory of semilinear evolution equations in the locally Lipschitz case and apply it to cubic wave equations in 3D. They can also examine these for global existence and blow-up. Based on the fundamentals of interpolation theory for generators, they can also deal with more general nonlinearities in the parabolic case. In this case, they can determine the long-term behaviour with the help of Lyapunov functions and the principle of linearized stability, and apply these results to reaction-diffusion systems. They can derive basic Strichartz inequalities. They can use them to treat the well-posedness and long-term behavior of the nonlinear Schrödinger and wave equations. They master the important proof techniques in the theory of semilinear evolution equations and can at least sketch more complex proofs.

Content

- semilinear evolution equations
- wellposedness, global existence versus blow-up
- interpolation theory for generators
- Lyapunov functions, linearized stability
- reaction diffusion systems
- semilinear wave and Schrödinger equations
- Strichartz inequalities

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the modules Functional Analysis and Evolution Equations are strongly recommended. However, the relevant parts of Evolution Equations will be briefly recalled.

2.138 Module: Nonlinear Functional Analysis [M-MATH-102886]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105876	Nonlinear Functional Analysis	3 CP	Herzog

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
None

Competence Goal
At the end of the course, students can

- name, discuss and apply basic techniques of nonlinear functional analysis,
- explain the construction of the Brouwer- and Schauder-degree,
- apply specific techniques of degree theory to nonlinear problems.

Content

- The Brouwer degree and its applications
- The Leray-Schauder degree and its applications
- Odd mappings
- Measures of non-compactness and their applications

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 hours

- lectures, problem classes, and examination

Self-studies: 60 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

2.139 Module: Nonlinear Maxwell Equations [M-MATH-105066]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-110283	Nonlinear Maxwell Equations	8 CP	Schnaubelt

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
Students can explain some basic types of nonlinear Maxwell equations and the physical significance of the variables that occur. They are able to prove and discuss local wellposedness theorems in the whole space using energy methods. They can derive Strichartz inequalities for linear Maxwell equations. With their help, they can show improved wellposedness results.

Content

- Maxwell equations with nonlinear material laws
- local wellposedness theory in the whole space using linearisation, apriori estimates and regularisation
- Strichartz inequalities and improved wellposedness theory

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the module "Functional Analysis" are strongly recommended.

M 2.140 Module: Nonlinear Wave Equations [M-MATH-105326]

Responsible: Prof. Dr. Wolfgang Reichel
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-110806	Nonlinear Wave Equations	4 CP	Reichel, Schnaubelt

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
Graduates will be able to

- name important properties of nonlinear wave equations,
- describe essential difficulties in the analysis of the initial value problem,
- analyze the short- and long-term behavior of solutions of semilinear wave equations using modern techniques.

Content
The aim of the course is an introduction to methods for analyzing nonlinear wave equations. The aim is to get to know the basics of various important techniques and to apply them to simple models. The following topics will be covered:

- Symmetries and conservation laws
- Fourier transformation, Sobolev spaces
- Energy estimates
- Strichartz estimates
- Local and global well-posedness results
- Vector field methods
- Longtime behavior

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 h

- lectures, problem classes and examination

Self studies: 75 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the module "Functional Analysis" are strongly recommended.

M 2.141 Module: Nonparametric Statistics [M-MATH-102910]

Responsible: PD Dr. Bernhard Klar
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-105873	Nonparametric Statistics	4 CP	Ebner, Fasen-Hartmann, Klar, Trabs

Assessment
The module will be completed with an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
By the end of the course, students will be able to

- explain nonparametric statistical tests based on location problems and distinguish them from parametric methods,
- name and explain nonparametric estimation methods for nonparametric regression and density estimation,
- know and apply optimality criteria for the statistical methods covered.

Content

- Introduction to nonparametric models
- Nonparametric tests, especially rank statistics
- Nonparametric density and regression estimation
- Dependence measures or optimal convergence rates

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 h

- lectures, problem classes and examination

Self studies: 75 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the module 'Probability Theory' are strongly recommended. The module 'Mathematical Statistics' is recommended.

M 2.142 Module: Numerical Analysis of Helmholtz Problems [M-MATH-105764]

Responsible: TT-Prof. Dr. Barbara Verfürth
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	German	4	2

Mandatory			
T-MATH-111514	Numerical Analysis of Helmholtz Problems	3 CP	Verfürth

Assessment
oral examination of circa 30 minutes

Prerequisites
none

Module Grade Calculation
The module grade is the grade of the final oral exam.

2.143 Module: Numerical Analysis of Neural Networks [M-MATH-106695]

Responsible: TT-Prof. Dr. Roland Maier
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113470	Numerical Analysis of Neural Networks	6 CP	Maier

Assessment
The module will be completed by an oral exam (about 30 min).

Prerequisites
None.

Competence Goal
The goal of the lecture is to provide a mathematical foundation of neural networks from the perspective of numerical analysis. Students know basic definitions and terminology as well as classical approximation results for neural networks. They are familiar with numerical methods for the efficient training of neural networks and can analyze them. Moreover, students can apply the concepts to popular applications (such as physics-informed neural networks, Deep Ritz method, etc.).

Content

- Neural networks
- Approximation results
- Connections to finite element methods
- Numerical methods for the efficient learning
- Datasets

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
The course is offered in English. If everybody speaks German, the lecture will be held in German.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
Basic knowledge of ordinary and/or partial differential equations as well as the contents of the module "Numerical Methods for Differential Equations" are recommended. Basic knowledge of functional analysis and finite element methods is helpful, but not required.

M 2.144 Module: Numerical Complex Analysis [M-MATH-106063]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-112280	Numerical Complex Analysis	6 CP	Hochbruck

Assessment
Oral exam of approximately 20 minutes.

Prerequisites
None.

Competence Goal
Graduates

- can apply techniques and concepts from complex analysis in numerical analysis,
- are prepared to write a thesis in numerical analysis.

Content
In this lecture we consider numerical methods for problems in complex analysis and complex analysis techniques to analyze numerical methods. It provides the chance to rediscover theorems known from the complex analysis lecture in applications.

The following topics are planned

- Calculations with power series: formal Newton's method and FFT,
- control systems and convolution quadrature (Cauchy integral formula, Laplace transform, argument principle),
- rational approximation to the exponential: order stars (maximum principle, argument principle),
- convergence of iterative methods for linear systems of equations an approximation of the matrix exponential operator (conformal mappings, Cauchy integral formula),
- numerical conformal mapping.

Module Grade Calculation
The module grade ist the grade of the oral exam.

Workload
Total workload: 180 h

Attendance: 60 h

- lectures, problem classes, and examination

Self-studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

Recommendations
Basic knowledge of complex analysis is highly recommended.

Literature
Lecture notes with references.

M 2.145 Module: Numerical Linear Algebra for Scientific High Performance Computing [M-MATH-103709]

Responsible: Prof. Dr. Hartwig Anzt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
5 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-MATH-107497	Numerical Linear Algebra for Scientific High Performance Computing	5 CP	Anzt

Prerequisites
None

2.146 Module: Numerical Linear Algebra in Image Processing [M-MATH-104058]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-108402	Numerical Linear Algebra in Image Processing	6 CP	Grimm

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
Graduates can name essential concepts of image processing using numerical linear algebra methods and implement them efficiently.

Content

- Linear models of optical devices
- Point spread function and discrete convolution
- Structured matrices and fast transformations
- Large, ill-conditioned linear systems of equations
- Krylov subspace methods, preconditioning
- Several applications

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

2.147 Module: Numerical Methods for Differential Equations [M-MATH-102888]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Tobias Jahnke

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	1

Mandatory			
T-MATH-105836	Numerical Methods for Differential Equations	8 CP	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

Assessment
Success is assessed in form of an oral or written examination. This will be determined by the lecturer at the beginning of the course.

Prerequisites
None

Competence Goal
At the end of the course, students

- know important examples of numerical methods for ordinary differential equations as well as the underlying construction principles
- are able to analyze the properties of these methods (in particular their stability, convergence and complexity)
- are able to analyze basic numerical methods for linear partial differential equations
- can explain concepts of modelling with differential equations

Content

- Numerical methods for initial value problems (Runge-Kutta methods, multistep methods, order, stability, stiff problems)
- Numerical methods for boundary value problems (finite difference methods for second-order elliptic equations)
- Numerical methods for initial boundary value problems (finite difference methods for parabolic equations and hyperbolic equations)

Module Grade Calculation
The module grade is the grade of the oral or written exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
It is highly recommended that participants have completed the modules "Numerische Mathematik 1 und 2" as well as "Programmieren: Einstieg in die Informatik und algorithmische Mathematik".

M 2.148 Module: Numerical Methods for Hyperbolic Equations [M-MATH-102915]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105900	Numerical Methods for Hyperbolic Equations	6 CP	Dörfler

Prerequisites
none

Competence Goal
.

M 2.149 Module: Numerical Methods for Integral Equations [M-MATH-102930]

Responsible: PD Dr. Tilo Arens
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105901	Numerical Methods for Integral Equations	8 CP	Arens, Hettlich

Assessment
The module examination is carried out by one oral examination (approx. 30 minutes).

By successfully participating in the problem classes by correctly completing 60% of the programming exercise assignments, students will obtain a bonus to the grade of the oral examination. This bonus amounts to an improvement of the grade to the next marking step (a decrease by 0.3 or 0.4, respectively), if the original grade is between 4.0 and 1.3.

Prerequisites
None

Competence Goal
Students are able to name and describe basic methods for numerically solving linear integral equations of the second kind, such as the Nyström method, collocation method and Galerkin method, as well as their underlying principles such as interpolation and numerical integration. They are able to apply these methods for numerically solving integral equations and to implement concrete examples on a computer. Students are able to state convergence results concerning these methods and have mastered the application of methods of proof for such results. They can independently derive corresponding results for simple variations of these methods and perform the analysis of the convergence behavior for specific applications.

Content

- Boundary integral operators
- Interpolation and quadrature formulae
- Nyström methods
- Projection methods and boundary element methods

Module Grade Calculation
The grade of the module is the grade of the oral examination, modified by the bonus from the problem class assignments.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- increased understanding of module content by wrapping up lectures at home
- work on exercises
- increased understanding of module content by self study of literature and internet research
- preparing for the examination

Recommendations
Numerical Analysis I

Integral Equations

M 2.150 Module: Numerical Methods for Maxwell's Equations [M-MATH-102931]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105920	Numerical Methods for Maxwell's Equations	6 CP	Hochbruck, Jahnke

Assessment
Oral examination of approximately 20 minutes.

Prerequisites
None.

Competence Goal
The students can interpret the terms arising in the time-dependent Maxwell equations physically and prove the existence and uniqueness of the solution under appropriate assumptions. They know numerical methods and techniques to approximate these solutions and they are able to perform an error analysis. From the practical point of view they are able to evaluate advantages and disadvantages of different methods.

Content
Maxwell equations are a set of vector valued partial differential equations that are fundamental for the propagation of electromagnetic waves in media. In this lecture we start to derive Maxwell equations in integral- and differential form, discuss examples of material laws, boundary conditions, and study the well-posedness in suitable function spaces. For the numerical solution of Maxwell equations, we employ finite element methods for the spatial discretization. Our emphasis is on discontinuous Galerkin methods. Favorable methods for time discretization are splitting methods, (locally) implicit schemes, and exponential integrators. We construct and analyse these methods and discuss their efficient implementation.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 h

Attendance: 60 h

- lectures, problem classes, and examination

Self-studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

Recommendations
Basic knowledge of ordinary and/or partial differential equations is recommended.

The module "Numerical Methods for Differential Equations" is strongly recommended.

Teaching and Learning Methods
Lecture and tutorial with the active contribution of the students; problem sheets every 2 weeks.

Literature
Lecture notes with many references will be provided.

M 2.151 Module: Numerical Methods for Oscillatory Differential Equations [M-MATH-106682]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-113437	Numerical Methods for Oscillatory Differential Equations	8 CP	Jahnke

Assessment
The module will be completed by an oral exam (about 30 min).

Prerequisites
none

Competence Goal
The central topic of the lecture are numerical time-integrators for highly oscillatory ordinary and partial differential equations.

After participation, students

- know selected classes of ordinary and partial differential equations with oscillatory solutions and can explain the reason for the oscillatons.
- can explain why time-integration of such problems with traditional methods is usually inefficient.
- know different techniques which can be used to construct more efficient methods for selected problems.
- can explain error bounds for such integrators and know the ideas, techniques and assumptions used in the error analysis.

Content

- Oscillatory ordinary and partial differential equations: examples and applications
- Construction of time integrators
- Oscillations and resonances
- Error analysis
- Space discretization by Fourier collocation methods

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
The module will be offered about every second summer semester.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations

Participants are expected to be familiar with numerical methods for ordinary differential equations (e.g. Runge-Kutta methods) and with concepts required for their analysis (stability, order, local and global error, etc.).

M 2.152 Module: Numerical Methods for Time-Dependent Partial Differential Equations [M-MATH-102928]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105899	Numerical Methods for Time-Dependent Partial Differential Equations	8 CP	Hochbruck, Jahnke

Assessment
Success is assessed in form of an oral examination lasting approx. 25 minutes.

Prerequisites
None.

Competence Goal
Students can analyze numerical methods for abstract evolution equations. They can understand current research results and master various techniques for proving stability and error estimates of time integration methods. They can independently solve exercises, and present and discuss solutions.

Content

- Time integration methods for linear, semilinear, and quasilinear evolution equations and their semi-discretization in place, in particular, implicit Runge-Kutta and multistep methods,
- rigorous error estimates and stability proofs.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 h

Attendance: 90 h

- lectures, problem classes, and examination

Self-studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

Recommendations
Numerical methods for differential equations, finite element methods, functional analysis.

M 2.153 Module: Numerical Methods in Computational Electrodynamics [M-MATH-102894]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105860	Numerical Methods in Computational Electrodynamics	6 CP	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

Prerequisites
none

M 2.154 Module: Numerical Methods in Fluid Mechanics [M-MATH-102932]

Responsible: Prof. Dr. Willy Dörfler
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-MATH-105902	Numerical Methods in Fluid Mechanics	4 CP	Dörfler, Thäter

Assessment
Oral exam of about 20 minutes.

Prerequisites
None

Competence Goal
Participants know about the modelling and physical basics that lead to the model equations. They know how to discretize fluidmechanical problems with the finite element method and know especiallly how to treat the incompressibility condition. They are able to analyze stability and convergence of the presented methods.

Content

- Modelling and derivation of the Navier-Stokes equations
- Mathematical and physical representation of energy and stress
- Lax-Milgram theorem, Céa lemma and saddle point theory
- Analytical and numerical treatment of the potential and Stokes flow
- Stability and convergence of the discrete models
- Numerical treatment of the stationary nonlinear equation
- Numerical treatment of the instationary problems
- Applications

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 h

- lectures, problem classes and examination.

Self studies: 75 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination.

Recommendations
Basic knowledge in the numerical treatment of differential equations, such as boundary value problems or initial value problems is strongly recommended. Knowledge in functional analysis is recommended.

2.155 Module: Numerical Methods in Mathematical Finance [M-MATH-102901]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-105865	Numerical Methods in Mathematical Finance	8 CP	Jahnke

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Competence Goal
The lecture concentrates on option pricing with numerical methods.

After participation, students

- know how to model the price dynamics of different types of options by stochastic or partial differential equations, and to evaluate the differences between these models.
- know, in particular, the assumptions on which these models are based, which enables them to discuss and question the meaningfulness and reliability of the models.
- know different methods for solving stochastic and partial differential equations numerically, and for solving high-dimensional integration problems.
- are able to implement and apply these methods to different types of options, and to analyze their stability and convergence.

Content

- Options, arbitrage and other basic concepts,
- Black-Scholes equation und Black-Scholes formulas,
- Numerical methods for stochastic differential equations,
- (Multilevel) Monte Carlo methods,
- (Quasi-)Monte Carlo integration,
- Numerical methods for Black-Scholes equations,
- Numerical methods for American options

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
The module is offered every second winter term.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations

Familiarity with stochastic differential equations, the Ito integral, and the Ito formula is strongly recommended. MATLAB skills are strongly recommended for the programming exercises.

2.156 Module: Numerical Optimisation Methods [M-MATH-102892]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105858	Numerical Optimisation Methods	8 CP	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

2.157 Module: Numerical Simulation in Molecular Dynamics [M-MATH-105327]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-110807	Numerical Simulation in Molecular Dynamics	8 CP	Grimm

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Graduates know the basic concepts for implementing numerical simulations in molecular dynamics on serial and parallel computer architectures. They can name the numerical results and procedures required for simulation in molecular dynamics, apply them to specific problems and implement them.

Content

- Linked-cell method for short-range potentials
- Parallel programming with MPI
- Various potentials and molecules
- Time integration methods
- Aspects of numerical geometric integration
- Methods for the simulation of long-range potentials

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-study: 150 hours

- follow-up and deepening of course content,
- work on problem sheets,
- literature study and internet research relating to the course content
- preparation for the module examination

Recommendations
The module M-MATH-102888 (Numerical Methods for Differential Equations) and some programming skills in C (or C++) are recommended.

2.158 Module: Optimal Control and Estimation [M-ETIT-102310]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Each summer term	1 term	German	1	1

Mandatory			
T-ETIT-104594	Optimal Control and Estimation	3 CP	Hohmann

Prerequisites
none

M 2.159 Module: Optimisation and Optimal Control for Differential Equations [M-MATH-102899]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105864	Optimisation and Optimal Control for Differential Equations	4 CP	

Prerequisites
none

2.160 Module: Optimization in Banach Spaces [M-MATH-102924]

Responsible: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-105893	Optimization in Banach Spaces	5 CP	Griesmaier, Hettlich

Assessment
The module will be completed by an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
The students can transfer properties from finite dimensional optimization problems to infinite dimensional cases. Furthermore, they can apply these results to problems from approximation theory, calculus of variation and optimal control. The students know about the main theorems and their proofs and can explain conclusions with the help of examples.

Content
Basics from Functional Analysis (in particular separation theorems, properties of convex functions and generalized derivatives), duality theory of convex problems, differentiable optimization problems (Lagrange multiplier), sufficient optimality conditions, existence results, applications in approximation theory, calculus of variation, and optimal control theory.

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 150 hours

Attendance: 60 hours

- lecture including course related examinations

Self-studies: 90 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research relating to the course content
- preparation for the module examination

Recommendations
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.

M 2.161 Module: Optimization of Dynamic Systems [M-ETIT-100531]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
5 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100685	Optimization of Dynamic Systems	5 CP	Hohmann

Assessment
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

Competence Goal
- The students know as well the mathematical basics as the fundamental methods and algorithms to solve constraint and unconstraint nonlinear static optimization problems.

- They can solve constraint and unconstraint dynamic optimization by using the calculus of variations approach and the Dynamic Programming method.

- Also they are able to transfer dynamic optimization problem to static problems.

- The students know the mathematic relations, the pros and cons and the limits of the particular optimization methods.

- They can transfer problems from other fields of their studies in a convenient optimization problem formulation and they are able to select and implement suitable optimization algorithms for them by using common software tools.

Content
The module teaches the mathematical basics that are required to solve optimization problems. The first part of the lecture treats methods for solving static optimization problems. The second part of the lecture focuses on solving dynamic optimization problems by using the method of Euler-Lagrange and the Hamilton method as well as the dynamic programming approach.

Module Grade Calculation
The module grade is the grade of the written exam.

Additional Information
Will be changed to 6 CR in winter term 25/26.

Workload
Each credit point stands for an amount of work of 30h of the student. The amount of work includes

1. presence in lecture/exercises/tutorial(optional) (2+1 SWS: 45h1.5 LP)
2. preparation/postprocessing of lecture/exercises (90h3 LP)
3. preparation/presence in the written exam (15h0.5 LP)

2.162 Module: Parallel Computing [M-MATH-101338]

Responsible: PD Dr. Mathias Krause
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-102271	Parallel Computing	5 CP	Krause, Wieners

Prerequisites
None

2.163 Module: Particle Physics I [M-PHYS-102114]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102369	Particle Physics I	8 CP	Ferber, Husemann, Klute, Quast, Rabbertz

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
Students can classify elementary particles and qualitatively analyze interactions between elementary particles using symmetries, Feynman diagrams and Lagrangian densities. Combining this knowledge with knowledge of elementary particle detection, students will be able to discuss the operation of modern particle physics detectors. Students will be able to interpret current data and figures from the scientific literature on particle physics and present the current state of research and important "open questions". Students will be able to apply techniques of statistical data analysis and Monte Carlo simulation to simple particle physics problems and perform basic characterization of silicon track detectors in the laboratory.

Content
Lecture:

- Basic concepts of particle physics
- Detectors and accelerators
- Basics of the Standard Model
- Tests of the electroweak theory
- Flavour physics
- QCD
- Physics at high transverse momenta
- Higgs physics
- Physics of massive neutrinos
- Physics beyond the Standard Model

Practical exercises:

- Current methods of Monte Carlo simulation and data analysis in particle physics.
- Measurements on modern silicon track detectors.

Additional Information
For students of the KIT Faculty of Computer Science: The exams in this module have to be registered via admissions from ISS (KIT Faculty of Computer Science). For this, an e-mail with matriculation numbers and name of the desired exam to Beratung-informatik@informatik.kit.edu is sufficient.

Workload
approx. 240 hours consisting of attendance time (60 hours), follow-up of the lecture incl. exam preparation and preparation of the exercises (180 hours)

Recommendations

Basic knowledge of experimental particle physics from the lecture Modern Experimental Physics III in the bachelor's program in physics.

Literature

M. Thomson: Modern Particle Physics, Cambridge University Press (2013). D. Griffith: Introduction to Elementary Particles, Wiley (2008). A. Bettini: Introduction to Elementary Particle Physics, Cambridge University Press (2008). C. Berger: Elementarteilchenphysik, Springer (2006).

Additional references will be given in lecture.

M 2.164 Module: Pattern Recognition [M-INFO-100825]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-101362	Pattern Recognition	6 CP	Beyerer, Zander

M 2.165 Module: Percolation [M-MATH-102905]

Responsible: Prof. Dr. Günter Last
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	2

Mandatory			
T-MATH-105869	Percolation	5 CP	Hug, Last, Winter

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
The students

- are acquainted with basic models of discrete and continuum percolation,
- acquire the skills needed to use specific probabilistic and graph-theoretical methods for the analysis of these models,
- know how to work self-organised and self-reflexive.

Content

- Bond and site percolation on graphs
- Infinite clusters and critical probabilities
- Asymptotics of cluster sizes
- Uniqueness of the infinite cluster
- Continuous percolation

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 150 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the module *Probability Theory* are recommended.

M 2.166 Module: Physical Foundations of Cryogenics [M-CIWVT-103068]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-CIWVT-106103	Physical Foundations of Cryogenics	6 CP	Grohmann

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
Understanding of the mechanisms of entropy generation, and the interaction of the first and the second law in thermodynamic cycles; understanding of cryogenic material properties; application, analysis and assessment of real gas models for classical helium I; understanding of quantum fluid properties of helium II based on Bose-Einstein condensation, understanding of cooling principles at lowest temperatures.

Content
Relation between energy and temperature, energy transformation on microscopic and on macroscopic scales, physical definitions of entropy and temperature, thermodynamic equlibria, reversibility of thermodynamic cycles, helium as classical and as quantum fluid, low-temperature material properties, cooling methods at temperatures below 1 K.

Module Grade Calculation
The grade of the oral examination is the module grade.

Workload
- Attendance time (Lecture): 45 h
- Homework: 45 h
- Exam Preparation: 90 h

Literature
Schroeder, D.V.: An introduction to thermal physics. Addison Wesley Longman (2000)

Pobell; F.: Matter and methods at low temperatures. 3rd edition, Springer (2007)

M 2.167 Module: Poisson Processes [M-MATH-102922]

Responsible: Prof. Dr. Günter Last
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
5 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105922	Poisson Processes	5 CP	Fasen-Hartmann, Hug, Last, Nestmann, Winter

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
The students know about important properties of the Poisson process. The focus is on probabilistic methods and results which are independent of the specific phase space. The students understand the central role of the Poisson process as a specific point process and as a random measure.

Content

- The Poisson process as particular point process
- Multivariate Mecke equation
- Superpositions, markings and thinnings
- Characterizations of the Poisson process
- Stationary Poisson and point processes
- Balanced allocations and the Gale-Shapley algorithm
- Compound Poisson processes
- Wiener-Ito integrals
- Fock space representation

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 150 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 90 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the module *Probability Theory* are recommended.

2.168 Module: Potential Theory [M-MATH-102879]

Responsible: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105850	Potential Theory	8 CP	Arens, Griesmaier, Hettlich, Reichel

Assessment
The module will be completed by an oral exam (30 min).

Prerequisites
None

Competence Goal
Students can explain basic properties of harmonic functions and prove existence and uniqueness of solutions to boundary value problems for the Laplace equation in interior and exterior domains using integral equation techniques. They master representation theorems and are able to apply single- and double layer potentials to solver boundary value problems.

Content

- Properties of harmonic functions
- Existence and uniqueness of boundary value problems for the Laplace equation
- Fundamental solutions and Green's functions
- Single- and double layer potentials
- Integral equations

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research relating to the course content
- preparation for the module examination

M 2.169 Module: Practical Course: Mathematical and Computational Methods in Robotics and AI [M-INFO-106933]

Responsible: Prof. Dr. Katja Mombaur
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each term	1 term	German/English	4	1

Mandatory			
T-INFO-113898	Practical Course: Mathematical and Computational Methods in Robotics and AI	6 CP	Mombaur

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students learn to understand scientific topics. They will learn how to address specific project tasks and solve them in a structured way. They will obtain deepened knowledge about fundamental mathematical and computational methods, including their potential, strengths and limitations and in which areas they are suited to be applied. Students learn to present their results to a an audience, as well as suitably documenting their results in form or in addition to a scientific paper and being capable of assessing the advantages and disadvantages of the methods used.

Content

Efficient mathematical and computational methods are an irreplaceable cornerstone of modern research and industrial applications in forms such as numerical simulation, optimization or inference, ranging from the generation of task-specific trajectories for robotic systems over stabilization of existing robots to data-driven prediction and inference as well as AI-applications.
In this practical course, students learn, on the basis of an individual programming project, how to implement and apply fundamental mathematical and computational methods to solve an existing task in a robotics application or related fields and gain experience leveraging methods from this area in said real-world context.

Additional Information
Limited number of projects and participants. Specific project topics will be different each term and will be announced in a presentation during the first semester week or can be indivdually agreed upon with people supervising the practical. Students can propose topics on their own as well.

Workload
Estimated effort for this module is 180 hours:
20h – In person events (kickoff meeting, individual meetings with supervisor, presentations)
130h – Individual project work
30h - Writing report and preparing presentation

Recommendations
Basic mathematical knowledge will be helpful, depending on topic. For Projects in the context of robotics, knowledge of robotics is recommended, but not strictly necessary.

2.170 Module: Probability Theory and Combinatorial Optimization [M-MATH-102947]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105923	Probability Theory and Combinatorial Optimization	8 CP	Hug, Last

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
The students

- know basic problems of combinatorial optimization as discussed in the lectures and are able to explain them,
- know typical methods for the probabilistic analysis of algorithms and combinatorial optimization problems and are able to use them for the solution of specific optimization problems,
- are familiar with the essential techniques of proof and are able to explain them,
- know how to work in a self-organized and self-reflexive manner.

Content
This course is devoted to the analysis of algorithms and combinatorial optimization problems in a probabilistic framework. A natural setting for the investigation of such problems is often provided by a (geometric) graph. For a given system (graph), the average or most likely behavior of an objective function of the system will be studied. In addition to asymptotic results, which describe a system as its size increases, quantitative laws for systems of fixed size will be described. Among the specific problems to be explored are

- the long-common-subsequence problem,
- packing problems,
- the Euclidean traveling salesperson problem,
- minimal Euclidean matching,
- minimal Euclidean spanning tree.

For the analysis of problems of this type, several techniques and concepts have been developed and will be introduced and applied in this course. Some of these are

- concentration inequalities and concentration of measure,
- subadditivity and superadditivity,
- martingale methods,
- isoperimetry,
- entropy.

Module Grade Calculation
The modul grade is the grade of the oral exam.

Workload

Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam.

Recommendations

It is recommended to have taken the module `Probability Theory' from the Bachelor program beforehand.

M 2.171 Module: Process Modeling in Downstream Processing [M-CIWVT-103066]

Responsible: apl. Prof. Dr. Matthias Franzreb
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-CIWVT-106101	Process Modeling in Downstream Processing	4 CP	Franzreb

Assessment
The examination is an oral examination with a duration of about 20 minutes (section 4 subsection 2 number 2 SPO).

The grade of the oral examination is the module grade.

Prerequisites
None

Competence Goal
Students are able to sum up and explain equilibrium and kinetic equations relevant for chromatography modeling. They are able to explain the methods used for determination of equilibrium and kinetic parameters and can discuss examples. They are familiar with the principle of complex downstream processes, e.g. simulated moving beds, and can explain the differences to conventional chromatography. Using commercial software they are able to simulate chromatography processes and to analyze the results. On this basis they can optimize process parameters and fit them in order to meet given targets such as purity or yield. They can evaluate different processes and choose the variant for a given task.

Content
Fundamentals and practical examples of chromatography modeling,

Design rules for Simulated Moving Beds, Design of Experiments (DOE)

Workload

- Attendance time (Lecture): 30 h
- Homework: 60 h
- Exam Preparation: 30 h

2.172 Module: Processing of Nanostructured Particles [M-CIWVT-103073]

Responsible: Prof. Dr.-Ing. Hermann Nirschl
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106107	Processing of Nanostructured Particles	6 CP	Nirschl

Assessment
Learning control is an oranl examination lasting approx. 25 minutes.

Prerequisites
None

Competence Goal
Ability to design a process technology for the manufacturing and production of nanoscale particles

Content
Development of technical process in particle engineering; particle characterisation, interface engineering, particle synthesis;
Typical processes: grinding, mixing, ganulation, selective separation,
classifying; fundamentals of apparatus and devices; simulation techniques, simulation tools

Module Grade Calculation
The grade of the oral examination is the module grade.

Workload

- Attendance time (Lecture): 60 h
- Homework: 60 h
- Exam Preparation: 60 h

Literature
Skriptum zur Vorlesung

M 2.173 Module: Random Graphs and Networks [M-MATH-106052]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112241	Random Graphs and Networks	8 CP	Hug

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
Students

- know the basic models of random graphs and their properties,
- are familiar with probabilistic techniques for the investigation of random graphs,
- are able to work in a self-organized and reflexive manner.

Content
In the course, models of random graphs and networks are presented and methods will be developed which allow to state and prove results about the structure of such models.

In particular, the following models are treated:

- Erdös--Renyi graphs
- Configuration models
- Preferential-Attachment graphs
- Generalized inhomogeneous random graphs
- Geometric random graphs

and the following methods are addressed:

- Branching processes
- Coupling arguments
- Probabilistic bounds
- Martingales
- Local convergence of random graphs

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Additional Information
can not be completed together with M-MATH-102951 - Random Graphs

Workload

Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam.

Recommendations

The contents of the module 'Probability Theory' are strongly recommended.

M 2.174 Module: Real-Time Systems [M-INFO-100803]

Responsible: Prof. Dr.-Ing. Thomas Längle
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101340	Real-Time Systems	6 CP	Längle

M 2.175 Module: Regularity for Elliptic Operators [M-MATH-106696]

Responsible: apl. Prof. Dr. Peer Kunstmann
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113472	Regularity for Elliptic Operators	6 CP	Kunstmann

Assessment
The module will be completed by an oral exam (about 30 min).

Prerequisites
none

Competence Goal
The students

- can explain methods for definition of elliptic operators,
- can name results on spectral properties in L^q and relate them,
- can explain the relevance of heat kernel estimates and sketch corresponding methods of proof,
- can sketch the construction of the H^\infty calculus and name classes of elliptic operators for which it is bounded,
- can explain the concept of L^p maximal regularity and its relation to other parts of the theory and can name exmaples,
- have mastered the important techniques of proofs for regulariy properties of elliptic operators,
- are able to start a master thesis in the field.

Content

- elliptic operators in divergence and non-divergence form
- elliptic operators on domains with boundary conditions
- heat kernel estimates for elliptic operators
- spectrum of elliptic operators in Lebesgue spaces L^q
- maximal L^p regularity for the parabolic problem
- H^\infty functional calculus for elliptic operators
- L^q theory for parabolic boundary value problems

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The modules “Functional Analysis” and "Spectral Theory" are strongly recommended.

2.176 Module: Riemann Surfaces [M-MATH-106466]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113081	Riemann Surfaces	8 CP	Herrlich

Assessment
Oral examination of ca. 30 minutes.

Prerequisites
None

Competence Goal
Students know

- essential structural properties of Riemann surfaces,
- topological, analytic and algebraic methods for the investigation of Riemann surfaces, and are able to apply them.

Content

- Definition of Riemann surfaces
- holomorphic and meromorphic functions on Riemann surfaces
- Compact Riemann surfaces
- The Riemann-Roch theorem
- Uniformization, Fuchsian groups and hyperbolic metric
- Classification of compact Riemann surfaces

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
Some knowledge of complex analysis (e.g. *"Analysis 4"*) is strongly recommended as well as the modules *"Elementary Geometry"* and *"Introduction to Algebra and Number Theory"*.

2.177 Module: Robotics I - Introduction to Robotics [M-INFO-107162]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-INFO-114190	Robotics I - Introduction to Robotics	6 CP	Asfour

Assessment
See partial achivements (Teilleistung)

Prerequisites
See partial achivements (Teilleistung)

Competence Goal
The students are able to apply the presented concepts to simple and realistic tasks from robotics. This includes mastering and deriving the mathematical concepts relevant for robot modeling. Furthermore, the students master the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The students know the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. They know algorithms from the field of image processing and are able to apply them to problems in robotics. They are able to model and solve tasks as a symbolic planning problem. The students have knowledge about intuitive programming procedures for robots and know procedures for programming and learning by demonstration.

Content
The lecture provides an overview of the fundamentals of robotics using the examples of industrial robots, service robots and autonomous humanoid robots. An insight into all relevant topics is given. This includes methods and algorithms for robot modeling, control and motion planning, image processing and robot programming. First, mathematical basics and methods for kinematic and dynamic robot modeling, trajectory planning and control as well as algorithms for collision-free motion planning and grasp planning are covered. Subsequently, basics of image processing, intuitive robot programming especially by human demonstration and symbolic planning are presented.

In the exercise, the theoretical contents of the lecture are further illustrated with examples. Students deepen their knowledge of the methods and algorithms by independently working on problems and discussing them in the exercise. In particular, students can gain practical programming experience with tools and software libraries commonly used in robotics.

Workload
Lecture with 3 SWS + 1 SWS Tutorial, 6 LP
6 LP corresponds to 180 hours, including
15 * 3 = 45 hours attendance time (lecture)
15 * 1 = 15 hours attendance time (tutorial)
15 * 6 = 90 hours self-study and exercise sheets
30 hours preparation for the exam

2.178 Module: Robotics II - Humanoid Robotics [M-INFO-102756]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Each summer term	1 term	English	4	3

Mandatory			
T-INFO-105723	Robotics II - Humanoid Robotics	3 CP	Asfour

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
The students have an overview of current research topics in autonomous learning robot systems using the example of humanoid robotics. They are able to classify and evaluate current developments in the field of cognitive humanoid robotics.

The students know the essential problems of humanoid robotics and are able to develop solutions on the basis of existing research.

Content
The lecture presents current work in the field of humanoid robotics that deals with the implementation of complex sensorimotor and cognitive abilities. In the individual topics different methods and algorithms, their advantages and disadvantages, as well as the current state of research are discussed.

The topics addressed are: Applications and real world examples of humanoid robots; biomechanical models of the human body, biologically inspired and data-driven methods of grasping, imitation learning and programming by demonstration; semantic representations of sensorimotor experience as well as cognitive software architectures of humanoid robots.

Workload
Lecture with 2 SWS, 3 CP.
3 LP corresponds to approx. 90 hours, thereof:
approx. 15 * 2h = 30 Std. Attendance time
approx. 15 * 2h = 30 Std. Self-study prior/after the lecture
approx. 30 Std. Preparation for the exam and exam itself

Recommendations
Having visited the lectures on Robotics I - Introduction to Robotics and Mechano-Informatics and Robotics is recommended.

M 2.179 Module: Robotics III - Sensors and Perception in Robotics [M-INFO-104897]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-109931	Robotics III - Sensors and Perception in Robotics	3 CP	Asfour

Assessment
See partial achivements (Teilleistung)

Prerequisites
See partial achivements (Teilleistung)

Competence Goal
Students can name the main sensor principles used in robotics.

Students can explain the data flow from physical measurement through digitization to the use of the recorded data for feature extraction, state estimation and semantic scene understanding.

Students are able to propose and justify suitable sensor concepts for common tasks in robotics.

Content
The lecture supplements the lecture Robotics I with a broad overview of sensors used in robotics. The lecture focuses on visual perception, object recognition, semantic scene interpretation, and (inter-)active perception. The lecture is divided into two parts:

In the first part a comprehensive overview of current sensor technologies is given. A basic distinction is made between sensors for the perception of the environment (exteroceptive) and sensors for the perception of the internal state (proprioceptive).

The second part of the lecture concentrates on the use of exteroceptive sensors in robotics. The topics covered include tactile exploration and visual data processing, including advanced topics such as feature extraction, object localization,semantic scene interpretation, and (inter-)active perception.

Workload
Lecture with 2 SWS, 3 LP
3 LP corresponds to 90 hours, including
15 * 2 = 30 hours attendance time
15 * 2 = 30 hours self-study
30 hours preparation for the exam

Recommendations
Attending the lecture Robotics I – Introduction to Robotics is recommended.

2.180 Module: Ruin Theory [M-MATH-104055]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-108400	Ruin Theory	4 CP	Fasen-Hartmann

Assessment
The module will be completed by an oral exam (approx. 20 min).

Prerequisites
None

Competence Goal
Students are able to

- name and discuss key concepts and results of ruin theory with applications in actuarial mathematics and can apply them to examples,
- apply specific probabilistic methods to analyse risk processes,
- master proof techniques,
- work in a self-orientated and reflective manner.

Content

- renewal theory
- classical risk process of Cramér and Lundberg
- asymptotic behaviour of the probability of ruin probability if the Lundberg constant exists (losses with light tailed distributions)
- subexponential distributions
- asymptotic behaviour of the probability of ruin if the losses are subexponentially distributed (losses with heavy tailed distributions)
- approximation of the ruin probability
- integrated risk processes
- portfolio of risk processes

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures and problem classes including the examination

Self studies: 75 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature and internet research on the course content
- preparation for the module examination

Recommendations
The content of the module "Probability Theory" is recommended.

M 2.181 Module: Sampling Methods for Machine Learning [M-INFO-107090]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-114133	Sampling Methods for Machine Learning	6 CP	Hanebeck
T-INFO-114134	Sampling Methods for Machine Learning - Pass	0 CP	Hanebeck

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students will understand and be able to implement various sampling techniques, from basic random number generation to advanced methods like normalizing flows. They will develop the ability to evaluate sampling quality, optimize procedures, and select appropriate methods for specific machine learning tasks. Graduates will be capable of independently developing sampling solutions for complex problems and critically assessing different approaches. Their comprehensive understanding will enable them to engage with current developments in the field and apply their knowledge effectively in both research and practical applications. This will be supported via a digital exercise.

Content
Sample-based inference is the de-facto standard for solving otherwise infeasible problems in machine learning, estimation, and control under (unavoidable) uncertainties. Thus, it is an important foundation for further studies. This lecture gives a thorough overview of state-of-the-art sampling methods and discusses current developments from the research frontier.

The first part shows how to efficiently sample large numbers of random samples from given densities starting with the special cases of uniform and Gaussian distributions. For sampling from arbitrary densities, important techniques such as inverse transform sampling, Knothe-Rosenblatt maps, Markov chain Monte Carlo, normalizing flows, and Langevin equations are introduced.

The second part is concerned with deterministic or low-discrepancy sampling, where the goal is to find a set of representative samples of a given density. These are usually obtained by optimization, which, in contrast to random samples, leads to good coverage, high homogeneity, and reproducible results. To analyze and synthesize such samples, various statistical tests and discrepancy measures are presented. This includes scalar tests such as the Cramér-von Mises test, Kolmogorov-Smirnov test, and multivariate generalizations based on Localized Cumulative Distributions and Stein discrepancy.

Finally, advanced topics such as importance sampling and sampling from the posterior density in a Bayesian update are discussed. Typical applications of sample-based inference include Bayesian neural networks, information fusion, and reinforcement learning.

Workload
Per week:
2 SWS Presence
2h Follow-up
6h Digital exercise with programming tasks
2h Exam preparation
= 12h/week und 180h/semester

Recommendations
Knowledge of a higher programming language with sophisticated libraries for scientific-numerical computing (e.g. Julia, Matlab, Python) is advantageous.

M 2.182 Module: Scattering Theory [M-MATH-102884]

Responsible: PD Dr. Frank Hettlich
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105855	Scattering Theory	8 CP	Arens, Griesmaier, Hettlich

Assessment
The module will be completed by an oral exam (~30min.)

Prerequisites
none

Competence Goal
The students can prove and apply basic properties of solutions of the Helmholtz equation in the interior and in the exterior of a domain. They know about the representation theorems for such solutions. Students can explain the existence theory of corresponding boundary value problems by integral equations and/or variational formulations including appropriate proofs. Furthermore, the students can show and apply the dependence of a scattered field on the scattering object and the wave number as well as the relationship with its far field pattern.

Content

- Helmholtz equation and elementary soultions
- Greens representation theorems
- Existence and uniqueness of scattering problems
- Radiation condition and far field pattern

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240h

Attendance: 90h

- lecture, problem class, examination

Self-studies: 150h

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam

Recommendations
One of the following modules should already be covered: functional analysis or integral equations

M 2.183 Module: Scattering Theory for Time-dependent Waves [M-MATH-106664]

Responsible: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113416	Scattering Theory for Time-dependent Waves	6 CP	Griesmaier

Assessment
The module will be completed with an oral exam of about 30 minutes.

Prerequisites
None

Competence Goal
The students can prove and apply basic properties of solutions of the wave equation in interior or exterior domains. They know about representation theorems for such solutions and can apply the Fourier-Laplace-transform to analyze causal solutions. Students master the existence and uniqueness theory of associated boundary value problems using integral equations and retarded single and double layer potentials including proofs. Furthermore, the students can apply these results to scattering problems and explain the depence of scattered waves on the scattering object as well as the relationship with its far field pattern.

Content

- Wave equations and elementary solutions
- Representation theorems
- Fourier-Laplace-transform
- Boundary element formulations of boundary value problems for the wave equation
- Existence and uniqueness of solutions to interior and exterior boundary value problems
- Scattering problems and far field patterns

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

Self studies: 120 h

Recommendations
The modules *Functional Analysis* and/or *Integral Equations* are recommended.

M 2.184 Module: Selected Methods in Fluids and Kinetic Equations [M-MATH-105897]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111853	Selected Methods in Fluids and Kinetic Equations	3 CP	

Assessment
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
The main aim of this lecture is to introduce students to tools and techniques developed in recent years to analyze the evolution of fluids and kinetic equations.
The students will learn how to use these techniques and how to apply them to families of equations.

Content
In this lecture we discuss selected techniques and tools that have lead to significant progress in the analysis of fluids and kinetic eqautions.
These, for instance, include:
- energy methods and local well-posedness results (e.g. fixed point results, Osgood lemma)
- Newton iteration
- Cauchy-Kowalewskaya and ghost energy approaches

No prior knowledge of fluids or kinetic equations is required.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 90 hours

Attendance: 30 h

- lectures and examination

Self studies: 60 h

- follow-up and deepening of the course content,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The modules "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

2.185 Module: Selected Topics in Harmonic Analysis [M-MATH-104435]

Responsible: Prof. Dr. Dirk Hundertmark
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-109065	Selected Topics in Harmonic Analysis	3 CP	Hundertmark

Prerequisites
None

Competence Goal
The students are familiar with the concepts of singular integral operators and weighted estimates in Harmonic Analysis. They know the relations between the BMO space and the Muckenhoupt weights and also how to use dyadic analysis operators to obtain estimates for Calderon-Zygmund operators.

Content
- Calderon-Zygmund and Singular Integral operators
- BMO space and Muckenhoupt weights
- Reverse Holder Inequality and Factorisation of Ap weights
- Extrapolation Theory and weighted norm inequalities for singular integral operators

M 2.186 Module: Semigroup Theory for the Navier-Stokes Equations [M-MATH-106663]

Responsible: Dr. rer. nat. Patrick Tolksdorf
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113415	Semigroup Theory for the Navier-Stokes Equations	6 CP	Tolksdorf

Assessment
The module will be completed with an oral exam of about 30 minutes.

Prerequisites
None

Competence Goal
After a successful participation of the course, students are familiar with essential concepts of semigroup theory, such as analytic semigroups and fractional powers of sectorial operators. They are able to apply these concepts to the Stokes operator and derive basic regularity properties of solutions to the Stokes equations. Furthermore, they can use these concepts to construct solutions to the Navier-Stokes equations in critical spaces through an iteration scheme.

Content
Content from abstract semigroup theory:

- Sectorial operators
- Analytic semigroups
- Fractional powers

Content from fluid mechanics:

- Helmholtz decomposition
- Bogovskii operator
- Stokes operator
- Mapping properties of the Stokes semigroup
- Solvability of the Navier-Stokes equations in critical spaces

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The following modules are strongly recommended: *Functional Analysis* and *Classical Methods for Partial Differential Equations.*

M 2.187 Module: Seminar [M-MATH-102730]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (mandatory)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	pass/fail	Each term	1 term	German/English	4	3

Elective Seminar (Election: 1 item)			
T-MATH-105686	Seminar Mathematics	3 CP	Kühnlein

Assessment
The control of success (pass/fail) is based on a seminar talk lasting at least 45 minutes.

Prerequisites
None

Competence Goal
At the end of the module, participants should

- have analyzed a specific problem in a mathematical area
- be able to discuss subject-specific problems in the given context and present as well as defend them, using suitable media
- have summarized the most relevant results of their topic
- have communicative, organizational and didactic skills in complex problem analyses at their disposal. They can use techniques of scientific work.

Content
The specific content is based on the seminar topics being offered.

Module Grade Calculation
Omitted, as ungraded (pass/fail)

Workload
Total work load: 90 hours

Attendance: 30 hours

Self studies: 60 hours

- Preparation of the scientific content of the talk
- Preparation of a didactical concept for the talk
- Preparation of the presentation (blackboard, beamer, etc.)
- getting practice for the talk, creating a hand-out

M 2.188 Module: Seminar Advanced Topics in Parallel Programming [M-INFO-101887]

Responsible: Prof. Dr. Achim Streit
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
3 CP	graded	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-103584	Seminar Advanced Topics in Parallel Programming	3 CP	Streit

M 2.189 Module: Signal Processing Methods [M-ETIT-106899]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113837	Signal Processing Methods	6 CP	Wahls

Assessment
Written exam, approx. 120 minutes.

Prerequisites
none

Competence Goal
Students can

- choose appropriate estimation methods based on theoretical properties and practical considerations
- determine estimators for specific problems
- can weight the pros and cons of data decomposition methods; apply them to given problems; interpret the results
- understand the advantages and limitations of the considered time-frequency analysis methods
- interpret time-frequency representations
- choose appropriate analysis and synthesis windows/wavelets
- determine time-frequency transforms of given signals

Content
This module introduces students to advanced signal processing methods that are widely employed in engineering. The three main topic areas are

1. Parameter estimation
2. Decomposition of data into components and modes
3. Time-frequency analysis

The following topics are treated:

- Best linear unbiased estimator
- Maximum likelihood estimation
- General Bayesian estimators
- Linear Bayesian estimators
- Principal component analysis
- Independent component analysis
- Dynamic and empirical mode decomposition
- Hilbert spaces and frames
- Short-time Fourier transform
- Wavelets
- Analytic signals
- Wigner-Ville-Distribution
- Huang-Hilbert transform

Illustrating examples from diverse application areas are discussed.

Module Grade Calculation
The module grade is the grade of the written exam.

Workload
The workload includes:

1. attendance in lectures and tutorials: 15*4 h = 60 h
2. preparation / follow-up: 15*4 h = 60 h
3. preparation of and attendance in examination: 60 h

A total of 180 h = 6 CR

Recommendations
Familiarity with signals and systems (in particular, Fourier transforms) and probability theory at the Bachelor level is assumed.

M 2.190 Module: Signal Processing with Nonlinear Fourier Transforms and Koopman Operators [M-ETIT-106675]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113428	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	6 CP	Wahls

Assessment
The examination in this module consists of programming assessments and a graded written examination of 120 minutes.

The programming assignments are either pass or fail. They must be passed during the lecture period for admission to the written examination.

Prerequisites
none

Competence Goal
Students

- understand the basic theory of linear operator on Hilbert spaces and can analyze simple operators analytically
- know the use cases for selected integrable partial differential equations (PDEs) and can apply them under non-ideal circumstances (small non-integrable terms)
- can determine the PDE corresponding to a given Lax-pair and check if the PDE is actually integrable (i.e. check if the Lax pair is “fake”)
- understand the theory of nonlinear Fourier analysis for selected PDEs and can compute nonlinear (inverse) Fourier transforms numerically and, in simple cases, analytically
- know and implement practical engineering applications of nonlinear Fourier transforms
- understand the theory of the Koopman operator including selected engineering applications
- compute Koopman spectra numerically using data-driven methods and use them in practical engineering applications

Content

This module introduces students to signal processing methods that rely on nonlinear Fourier transforms and Koopman operators. These methods allow us to transform large classes of nonlinear systems such that they essentially behave like linear systems. They can also be used to decompose signals driven by such systems into physically meaningful nonlinear wave components (for example, solitons).

While these methods originated in mathematical physics, there has been a growing interesting of exploiting their unique capabilities in engineering contexts. The goal of this module is to give engineering students a practical introduction to this area. It provides the necessary theoretical background, enables students to apply the methods in practice via computer assignments, and discusses recent research from the engineering literature.

The following topics will be discussed:

- Introduction to linear operators on Hilbert spaces
- Integrable model systems (Korteweg-de Vries equation, Nonlinear Schrödinger equation)
- Lax-integrable systems (representations of Lax pairs, fake Lax pairs, conserved quantities)
- Solution of integrable model systems using nonlinear Fourier transforms (inverse scattering method) and the unified transform method
- Physical interpretation of nonlinear Fourier spectra (in particular, solitons)
- Practical applications of nonlinear Fourier transforms
- Theoretical properties of Koopman operators
- Data-driven computation of Koopman operators (residual dynamic mode decomposition)
- Practical applications of Koopman operators

Module Grade Calculation

The module grade is the grade of the written exam.

Additional Information

Some tutorial sessions will be classically devoted to solving pen and paper problems, but in others students will be working on their practical computer assignments. For the latter, students have to bring their own laptops with Matlab installed. The solutions of the computer assignments must be submitted by the provided deadlines, which are typically one week after the corresponding tutorial has taken place.

Workload

The workload includes:

1. attendance in lectures and tutorials: 15*4 h = 60 h
2. preparation / follow-up: 30*3 h = 60 h
3. finishing programming assignments: 30 h
4. preparation of and attendance in examination: 30 h

A total of 180 h = 6 CR

Recommendations

Familiarity with signals and systems at the Bachelor level (Fourier and Laplace transforms, linear systems, etc.) is assumed.

2.191 Module: Simulation and Optimization in Robotics and Biomechanics [M-INFO-106504]

Responsible: Prof. Dr. Katja Mombaur
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-INFO-113123	Simulation and Optimization in Robotics and Biomechanics	6 CP	Mombaur

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
The students
• can explain advanced principles of modeling, optimization and control of dynamic processes, in particular mechanical systems and can apply them
• can model, classify and analyze complex motions in robotics or biomechanics, and investigate specific properties such as stability.
• can apply nonlinear optimization and optimal control methods and can compare and evaluate different mathematical approaches.
• know how to use software tools based on C++ and Lua for modeling, simulation, optimization and visualization of humanoid and robotic systems
are capable of solving optimal control problems numerically and to evaluate the quality of the solution.

Content
The goal of this course is to give a practical introduction into simulation and optimization of motions in robotics and biomechanics. Simulation and optimization play an important role in generating and controlling motions in complex robotics systems and in predicting and analyzing motions of humans. Theory and methods will be covered, but the focus is on the use software tools for modeling, simulation, optimization and visualization of multibody systems. Topics covered include:
- Dynamic process modeling
- Transforming real world problems into mathematical models
- Modeling of complex robotics and biomechanics systems (e.g. humanoids), based on previous modeling knowledge
- Common template models for bipedal walking and running in robotics and biomechanics
- Simulation of mechanical / robotics systems (Integrators and Initial value problems)
- Boundary value problems
- Nonlinear optimization problems
- Optimal control problems
- Direct and indirect methods for optimal control problems, focus on direct methods, especially direct multiple shooting
- Stability of dynamical systems, stability in biomechanics and robotics

Additional Information
Limitation to 30 participants

Workload
Estimated effort for this module is 180 hours:
60h - Lecture and exercises (2+2 SWS)
80h - Independent work (repetition of lecture contents, preparation of assignments
40h - Exam preparation

M 2.192 Module: Sobolev Spaces [M-MATH-102926]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German/English	4	2

Mandatory			
T-MATH-105896	Sobolev Spaces	8 CP	Schnaubelt

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
Students can explain the significance of Sobolev spaces for partial differential equations and apply the theory to examples. They are able to reproduce and prove the basic properties of the spaces and to describe the central methods. They can discuss the central theorems and their significance and describe the main ideas of the proofs.

Content
Definition of Sobolev spaces for functions on Lipschitz domains; density and extension results; product, composition and interpolation estimates; embeddings including compactness, traces, duality; Helmholtz decomposition in R^3; simple applications to partial differential equations.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The module "Functional Analysis" is strongly recommended.

M 2.193 Module: Software Engineering II [M-INFO-107235]

Responsible: Prof. Dr.-Ing. Anne Koziolek
Prof. Dr. Raffaela Mirandola
Prof. Dr. Ralf Reussner

Organisation: KIT Department of Informatics

Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-114259	Software Engineering II	6 CP	Koziolek, Mirandola, Reussner

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal

Software processes: Students understand evolutionary and incremental development and can describe the advantages over the sequential approach. They can describe the phases and disciplines of the unified process.

Requirements engineering: Students can describe the terms of requirements engineering and name activities in the requirements engineering process. They can classify and assess requirements according to the facets of type and representation. They can apply basic guidelines for specifying natural language requirements and describe prioritization procedures for requirements. Describe the purpose and elements of use case models. You can classify use cases according to their granularity and objectives. You can create use case diagrams and use cases. They can derive system sequence diagrams and operation contracts from use cases and can describe their role in the software development process.

Software architecture: Students can reproduce and explain the definition of software architecture and software components. They can explain the difference between software architecture and software architecture documentation. They can describe the advantages of explicit architecture and the factors influencing architecture decisions. You can assign design decisions and elements to the layers of an architecture. You will be able to describe what component models define. They can describe the components of the Palladio component model and discuss some of the design decisions made.

Enterprise Software Patterns: Students can characterize enterprise applications and decide for a described application which properties it fulfills. They know patterns for structuring domain logic, architectural patterns for data access and object-relational structure patterns. They can select a suitable pattern for a design problem and justify the selection based on the advantages and disadvantages of the patterns.

Software design: Students can assign the responsibilities resulting from system operations to classes or objects in object-oriented design using the GRASP patterns and thus design object-oriented software.

Software quality: Students know the principles for readable program code, can identify violations of these principles and develop proposals for solutions.

Model-driven software development: Students can describe the goals and the idealized division of labor of model-driven software development (MDSD) and reproduce and explain the definitions for model and metamodel. They can discuss the goals of modeling. You will be able to describe the model-driven architecture and express constraints in the Object Constraint Language. You can express simple transformation fragments of model-to-text transformations in a template language. You can weigh up the advantages and disadvantages of MDSD.

Embedded systems: Students will be able to explain the principle of a real-time system and why they are usually implemented as parallel processes. They can describe a rough design process for real-time systems. They can describe the role of a real-time operating system. They can distinguish between different classes of real-time systems.

Reliability: Students can describe the various dimensions of reliability and categorize a given requirement. They can illustrate that unit tests are not sufficient to evaluate software reliability and can describe how usage profile and realistic error data have an influence.

Domain-driven design (DDD): Students are familiar with the design metaphor of ubiquitous language, Closed Contexts, and Strategic Design. They can describe a domain using the DDD concepts, entity, value objects, services, and improve the resulting domain model using the patterns of aggregates, factories, and depots. They know the different types of interactions between Closed Contexts and can apply them.

Security (in the sense of security): Students can describe the basic ideas and challenges of security assessment. They can recognize common security problems and propose solutions.

Content

Requirements engineering, software development processes, software quality, software architectures, MDD, Enterprise Software Patterns software maintainability, software security, dependability, embedded software, middleware, domain-driven design

Additional Information

The Software Engineering II module is a basic module.

Workload

Preparation and follow-up time 1.5 h / 1 SWS

Total workload:
(4 SWS + 1.5 x 4 SWS) x 15 + 30 h exam preparation = 180 h = 6 ECTS

2.194 Module: Space and Time Discretization of Nonlinear Wave Equations [M-MATH-105966]

Responsible: Dr. rer. nat. Benjamin Dörich
Prof. Dr. Marlis Hochbruck

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112120	Space and Time Discretization of Nonlinear Wave Equations	6 CP	Hochbruck

Assessment
Oral exam of approximately 20 minutes.

Prerequisites
None.

Competence Goal
Graduates

- can name and discuss essential concepts of error analysis of space and time discretizations for nonlinear wave equations,
- are prepared to write a thesis in the field of numerics of partial differential equations.

Content
The topic of the lecture is a unified error analysis of the space and time discretization of nonlinear wave-like equations. For this purpose, evolution equations with monotone operators on Hilbert spaces and different types of space discretization are considered, e.g. finite elements, discontinuous Galerkin methods or spectral methods, and, in particular, non-conformal discretizations.

After the analysis of the space discretization errors, this is combined with time integration methods such as the Crank-Nicolson and an implicit-explicit method.

The abstract analysis is illustrated with concrete examples.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 180 h

Attendance: 60 h

- lectures, problem classes, and examination

Self-studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

Recommendations
Basic knowledge of partial differential equations and the contents of the modules M-MATH-102888 - Numerische Methoden für Differentialgleichungen and M-MATH-102891 - Finite Elemente Methoden are strongly recommended. Knowledge of functional analysis is also recommended.

M 2.195 Module: Spatial Stochastics [M-MATH-102903]

Responsible: Prof. Dr. Günter Last
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each winter term	1 term	4	1

Mandatory			
T-MATH-105867	Spatial Stochastics	8 CP	Hug, Last, Winter

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
none

Competence Goal
The students are familiar with some basic spatial stochastic processes. They do not only understand how to deal with general properties of distributions, but also know how to describe and apply specific models (Poisson process, Gaussian random fields). They know how to work self-organised and self-reflexive.

Content

- Random sets
- Point processes
- Random measures
- Palm distributions
- Random fields
- Gaussian fields
- Spectral theory of random fields
- Spatial ergodic theorem

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the module *Probability Theory* are recommended.

M 2.196 Module: Special Topics of Numerical Linear Algebra [M-MATH-102920]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	see Annotations	1 term	English	4	1

Mandatory			
T-MATH-105891	Special Topics of Numerical Linear Algebra	8 CP	Grimm, Hochbruck, Neher

Assessment
Oral exam of approximately 30 minutes.

Prerequisites
None.

Competence Goal
At the end of the course, students possess informed knowledge of methods and concepts of numerical linear algebra for large matrices. For various applications, they choose and implement the right numerical methods and they are able to assess and establish convergence properties of these methods. Students are able to solve problems in a self-organized and reflective manner, and to present and discuss solutions.

Content

- Direct methods for sparse linear systems
- Krylov subspace methods for large linear systems and eigenvalue problems
- matrix functions

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
Bi-yearly course.

Workload
Total workload: 240 h

Attendance: 90 h

- lectures, problem classes, and examination

Self-studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination.

Recommendations
Numerical analysis 1 and 2.

2.197 Module: Spectral Theory [M-MATH-101768]

Responsible: Prof. Dr. Dorothee Frey
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Each summer term	1 term	German	4	1

Mandatory			
T-MATH-103414	Spectral Theory - Exam	8 CP	Frey, Herzog, Kunstmann, Schnaubelt, Tolksdorf

Assessment
Oral examination of approx. 30 minutes.

Prerequisites
none

Competence Goal
After participation, students

- understand the concepts of spectrum and resolvent of closed operators on Banach spaces.
- know their basic properties and are able to explain them in simple examples.
- can explain and justify the special features of compact operators and the Fredholm Alternative.
- can deduce algebraic identities and norm bounds for operators by means of the Dunford functional calculus and the spectral calculus for self-adjoint operators. This in particular includes spectral projections and spectral mapping theorems.
- are able to apply this general theory to integral and differential equations, and recognize the importance of spectral theoretic methods in Analysis.

Content

- Closed operators on Banach spaces,
- Spectrum and resolvent,
- Compact operators and Fredholm alternative,
- Dunford functional calculus, spectral projections,
- Fourier transform,
- Unbounded self-adjoint operators on Hilbert spaces,
- Spectral theorem,
- Sesquilinear forms and sectorial operators,
- Applications to partial differential equations.

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 h

- lectures, problem classes and examination

Self studies: 150 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The module „Functional Analysis“ is strongly recommended.

M 2.198 Module: Spectral Theory of Differential Operators [M-MATH-102880]

Responsible: Prof. Dr. Michael Plum
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105851	Spectral Theory of Differential Operators	8 CP	Plum

M 2.199 Module: Splitting Methods for Evolution Equations [M-MATH-105325]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-110805	Splitting Methods for Evolution Equations	6 CP	Jahnke

Assessment
The module will be completed by an oral exam (about 30 min).

Prerequisites
None

Competence Goal
After attending the course, students can explain the concept and the advantages of splitting methods. They know important examples of such methods and typical problem classes to which these methods can be applied. They can explain the relation between classical order and accuracy, and they know the (classical) order conditions of such methods. Students can reproduce and explain error estimates for splitting methods for linear and nonlinear evolution equations, and to explain the essential steps of the proof as well as the relevance of the made assumptions.

Content

- Concept and advantages of splitting methods
- Splitting methods for ordinary differential equations
- Baker-Campbell-Hausdorff formula and order conditions
- Tools from operator theory
- Splitting methods for linear evolution equations (Schrödinger equation, parabolic problems)
- Splitting methods for nonlinear evolution equations (nonlinear Schrödinger equation, Gross-Pitaevskii equation, Korteweg-de Vries equation)

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
The module will be offered about every second summer semester.

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Familiarity with ordinary differential equations and Runge-Kutta methods (construction, order, stability) is strongly recommended.

M 2.200 Module: Statistical Learning [M-MATH-105840]

Responsible: Prof. Dr. Mathias Trabs
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each summer term	1 term	4	1

Mandatory			
T-MATH-111726	Statistical Learning	8 CP	Trabs

Assessment
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Competence Goal
At the end of the course, students

- know the fundamental principles and problems of machine learning and can relate learning methods to these,
- are able to explain how selected machine learning methods work and can apply these,
- are able to derive and to discuss a statistical analysis of selected learning methods,
- are able to independently develop and apply new learning methods.

Content
The course aims for a rigorous and mathematical analysis of some popular machine learning methods with a focus is on statistical aspects. Topics are:

- Regression
  - Empirical risk minimization
  - Lasso
  - Regression trees and Random forests
- Classification
  - Bayes classifier
  - model based classifiers (e.g. logistic regression, discriminant analysis)
  - model-free classifiers (e.g. k nearest neighbors, support vector machines)
- Neural networks
  - training
  - approximation properties
  - statistical analysis
- Unsupervised learning
  - principle component analysis
  - clustering
  - generative models

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The modules "Probability Theory" and "Statistics" (M-MATH-103220) are recommended.

M 2.201 Module: Statistical Thermodynamics [M-CIWVT-103059]

Responsible: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	German/English	4	3

Mandatory			
T-CIWVT-106098	Statistical Thermodynamics	6 CP	Enders

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
Thermodynamics III

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The module M-CIWVT-103058 - Thermodynamics III must have been passed.

Competence Goal
The students are able to understand the basics of statistical mechanics and they are able to recognize the advantage and disadvantage for application in chemical engineering.

Content
Boltzmann-method, Gibbs-method, real gases, quations of state, polymers

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
If required, the course will be offered in English.

Literature

- J. Blahous, Statistische Thermodynamik, Hirzel Verlag Stuttgart, 2007.
- H.T. Davis, Statistical Mechanics of Phases, Interfaces, and Thin Films, Wiley-VCH, New York, 1996.
- G.G, Gray, K.E. Gubbins, Theory of Molecular Fluids Fundamentals. Clarendon, Press Oxford, 1984.
- J.P. Hansen, I.R. McDonald, Theory of Simple Liquids with Application to Soft Matter. Fourth Edition, Elsevier, Amsterdam, 2006.
- G.H. Findenegg, T. Hellweg, Statistische Thermodynamik, 2. Auflage,
- Springer Verlag, 2015.
- J.O. Hirschfelder, C.F. Curtis, R.B. Bird, Molecular Theory of Gases and Liquids. John-Wiley & Sons, New York, 1954.

2.202 Module: Steins Method with Applications in Statistics [M-MATH-105579]

Responsible: Dr. rer. nat. Bruno Ebner
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-111187	Steins Method with Applications in Statistics	4 CP	Ebner, Hug

Prerequisites
None

2.203 Module: Stochastic Control [M-MATH-102908]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105871	Stochastic Control	4 CP	Bäuerle

Assessment
The module will be completed by an oral exam (about 20 min).

Prerequisites
none

Competence Goal
At the end of the course, students

- can name the mathematical foundations of stochastic control and and are able to apply solution techniques,
- can formulate continuous-time dynamic stochastic optimization problems as stochastic control problems,
- are able to work in a self-organized and reflective manner,

Content

- Verification techniques, Hamilton-Jacobi-Bellman equation
- Viscosity solution
- Singular control
- Feynman-Kac representations
- Applications from finance and insurance

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures, problem classes, and examination

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course 'Probably Theory' is strongly recommended. The courses 'Brownian motion' and 'Continuous time finance' are recommended.

2.204 Module: Stochastic Differential Equations [M-MATH-102881]

Responsible: Prof. Dr. Dorothee Frey
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105852	Stochastic Differential Equations	8 CP	Frey, Schnaubelt

Content

- Brownian motion
- Martingales and Martingal inequalities
- Stochastic integrals and Ito's formula
- Existence and uniqueness of solutions for systems of stochastic differential equations
- Perturbation and stability results
- Application to equations in financial mathematics, physics and engineering
- Connection with diffusion equations and potential theory

2.205 Module: Stochastic Geometry [M-MATH-102865]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Each summer term	1 term	4	1

Mandatory			
T-MATH-105840	Stochastic Geometry	8 CP	Hug, Last, Winter

Assessment
The module will be completed by an oral exam (ca. 30 min).

Prerequisites
None

Competence Goal
The students

- know the fundamental geometric models and characteristics in stochastic geometry,
- are familiar with properties of Poisson processes of geometric objects,
- know examples of applications of models of stochastic geometry,
- know how to work self-organised and self-reflexive.

Content

- Random Sets
- Geometric Point Processes
- Stationarity and Isotropy
- Germ Grain Models
- Boolean Models
- Foundations of Integral Geometry
- Geometric densities and characteristics
- Random Tessellations

Module Grade Calculation
The modul grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content
- work on problem sheets
- literature study and internet research related to the course content
- preparation for the module exam.

Recommendations
It is recommended to have taken the module 'Spatial Stochastics' beforehand.

M 2.206 Module: Stochastic Information Processing [M-INFO-100829]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101366	Stochastic Information Processing	6 CP	Hanebeck

2.207 Module: Stochastic Simulation [M-MATH-106053]

Responsible: Prof. Dr. Sebastian Krumscheid
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
5 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-MATH-112242	Stochastic Simulation	5 CP	Krumscheid

Assessment
oral exam of ca. 30 min

Prerequisites
None

Competence Goal
After successfully taking part in the module's classes and the exam, students will be acquainted with sampling-based computational tools used to analyze systems with uncertainty arising in engineering,
physics, chemistry, and economics. Specifically, by the end of this course, students will be able to analyze the convergence of sampling algorithms and implement the discussed sampling methods for different
stochastic processes as computer codes. Understanding the advantages and disadvantages of different sampling-based methods, the students can, in particular, choose appropriate stochastic simulation
techniques and propose efficient sampling methods for a specific stochastic problem. In particular, they can name and discuss essential theoretical concepts, and understand the structure of the sampling-based computational methods. Finally, the course prepares students to write a thesis in the field of Uncertainty Quantification.

Content
The course covers mathematical concepts and computational tools used to analyze systems with uncertainty arising across various application domains. First, we will address stochastic modelling strategies to represent uncertainty in such systems. Then we will discuss sampling-based methods to assess uncertain system outputs via stochastic simulation techniques. The focus of this course will be on
the theoretical foundations of the discussed techniques, as well as their methodological realization as efficient computational tools. Topics covered include:

- Random variable generation
- Simulation of random processes
- Simulation of Gaussian random fields
- Monte Carlo method; output analysis
- Variance reduction techniques
- Rare event simulations
- Quasi Monte Carlo methods
- Markov Chain Monte Carlo methods (Metropolis-Hasting, Gibbs sampler)

Module Grade Calculation
The grade of the module is the grade of the oral exam.

Workload
total workload: 150 hours

Recommendations
The contents of the modules 'M-MATH-101321 - Introduction to Stochastics' and 'M-MATH-103214 – Numerical Mathematics 1+2' are recommended.

M 2.208 Module: Structural Graph Theory [M-MATH-105463]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111004	Structural Graph Theory	4 CP	Aksenovich

Prerequisites
None

Competence Goal
After successful completion of the course, the participants should be able to present and analyse main results in Structural Graph Theory. They should be able to establish connections between graph minors and other graph parameters, give examples, and apply fundamental results to related problems.

Content
The purpose of this course is to provide an introduction to some of the central results and methods of structural graph theory. Our main point of emphasis will be on graph minor theory and the concepts devised in Robertson and Seymour's intricate proof of the Graph Minor Theorem: in every infinite set of graphs there are two graphs such that one is a minor of the other.

Our second point of emphasis (time permitting) will be on Hadwiger's conjecture: that every graph with chromatic number at least r has a K_r minor. We shall survey what is known about this conjecture, including some very recent progress.

Recommendations
A solid background in the fundamentals of graph theory.

2.209 Module: Supplementary Studies on Science, Technology and Society [M-FORUM-106753]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation: General Studies. Forum Science and Society (FORUM)

Part of: Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
16 CP	graded	Each term	3 terms	German	4	1

Election Notes

Students have to self-record the achievements obtained in the Supplementary Studies on Science, Technology and Society in their study plan. FORUM (formerly ZAK) records the achievements as "non-assigned" under "ÜQ/SQ-Leistungen". Further instructions on self-recording of achievements can be found in the FAQ at https://campus.studium.kit.edu/ and on the FORUM homepage at https://www.forum.kit.edu/english/. The title of the examination and the amount of credits override the modules placeholders.

If you want to use FORUM achievements for both your Interdisciplinary Qualifications and for the Supplementary Studies, please record them in the Interdisciplinary Qualifications first. You can then get in contact with the FORUM study services (stg@forum.kit.edu) to also record them in your Supplementary Studies.

In the Advanced Unit you can choose examinations from three subject areas: "About Knowledge and Science", "Science in Society" and "Science in Social Debates". It is advised to complete courses from each of the three subject areas in the Advanced Unit.

To self-record achievements in the Advanced Unit, you have to select a free placeholder partial examination first. The placeholders' title do *not* affect which achievements the placeholder can be used for!

Mandatory			
T-FORUM-113578	Lecture Series Supplementary Studies on Science, Technology and Society - Self Registration	2 CP	Mielke, Myglas
T-FORUM-113579	Basic Seminar Supplementary Studies on Science, Technology and Society - Self Registration	2 CP	Mielke, Myglas
Advanced Unit Supplementary Studies on Science, Technology and Society (Election: at least 12 credits)			
T-FORUM-113580	Elective Specialization Supplementary Studies on Science, Technology and Society / About Knowledge and Science - Self-Registration	3 CP	Mielke, Myglas
T-FORUM-113581	Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Society - Self-Registration	3 CP	Mielke, Myglas
T-FORUM-113582	Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Public Debates - Self Registration	3 CP	Mielke, Myglas
Mandatory			
T-FORUM-113587	Registration for Certificate Issuance - Supplementary Studies on Science, Technology and Society	0 CP	Mielke, Myglas

Assessment

The monitoring is explained in the respective partial achievement.

They are composed of:
- Protocols
- Reflection reports
- Presentations
- Preparation of a project work
- An individual term paper
- An oral examination
- A written exam

Upon successful completion of the supplementary studies, graduates receive a graded report and a certificate issued by the FORUM.

Prerequisites
The course is offered during the course of study and does not have to be completed within a defined period. Enrollment is required for all assessments of the modules in the supplementary studies.
Participation in the supplementary studies is regulated by § 3 of the statutes. KIT students register for the supplementary studies by selecting this module in the student portal and booking a performance themselves. Registration for courses, assessments, and exams is regulated by § 8 of the statutes and is usually possible shortly before the start of the semester.
The course catalog, module description (module manual), statutes (study regulations), and guidelines for creating the various written performance requirements can be downloaded from the FORUM homepage at **https://www.forum.kit.edu/begleitstudium-wtg.php**.

Registration and exam modalities
PLEASE NOTE:
Registration on the FORUM, i.e. additionally via the module selection in the student portal, enables students to receive up-to-date information about courses or study modalities. In addition, registering on the FORUM ensures that you have proof of the credits you have earned. As it is currently (as of winter semester 24-25) not yet possible to continue additional credits acquired in the Bachelor's programme electronically in the Master's programme, we strongly advise you to digitally secure the credits you have earned by archiving the Bachelor's transcript of records yourself and by registering on FORUM.
In the event that a transcript of records of the Bachelor's certificate is no longer available - we can only assign the achievements of registered students and thus take them into account when issuing the certificate.

Competence Goal
Graduates of the Supplementary Studies on Science, Technology, and Society gain a solid foundation in understanding the interplay between science, the public, business, and politics. They develop practical skills essential for careers in media, political consulting, or research management. The program prepares them to foster innovation, influence social processes, and engage in dialogue with political and societal entities. Participants are introduced to interdisciplinary perspectives, encompassing social sciences and humanities, to enhance their understanding of science, technology, and society. The teaching objectives of this supplementary degree program include equipping participants with both subject-specific knowledge and insights from epistemological, economic, social, cultural, and psychological perspectives on scientific knowledge and its application in various sectors. Students are trained to critically assess and balance the implications of their actions at the intersection of science and society. This training prepares them for roles as students, researchers, future decision-makers, and active members of society.

Through the program, participants learn to contextualize in-depth content within broader frameworks, independently analyze and evaluate selected course materials, and communicate their findings effectively in both written and oral formats. Graduates are adept at analyzing social issues and problem areas, reflecting on them critically from a socially responsible and sustainable standpoint.

Content

The Supplementary Studies on Science, Technology and Society can be started in the 1st semester of the enrolled degree programme and is not limited in time. The wide range of courses offered by FORUM makes it possible to complete the program usually within three semesters. The supplementary studies comprises 16 or more credit points (LP). It consists of **two modules: the Basic Module (4 LP) and the Advanced Module (12 LP).**

The **basic Module** comprises the compulsory courses ‘Lecture Series Supplementary Studies on Science, Technology and Society’ and a basic seminar with a total of 4 LP.

The **Advanced Module** comprises courses totalling 12 LP in the humanities and social sciences subject areas ‘On Knowledge and Science’, ‘Science in Society’ and ‘Science in Public Debates’. The allocation of courses to the accompanying study programme can be found on the homepage https://www.forum.kit.edu/wtg-aktuelland in the printed FORUM course catalogue.

The 3 thematic subject areas:

Subject area 1: About Knowledge and Science

This is about the internal perspective of science: students explore the creation of knowledge, distinguishing between scientific and non-scientific statements (e.g., beliefs, pseudo-scientific claims, ideological statements), and examining the prerequisites, goals, and methods of knowledge generation. They investigate how researchers address their own biases, analyze the structure of scientific explanatory and forecasting models in various disciplines, and learn about the mechanisms of scientific quality assurance.

After completing courses in the "Knowledge and Science" area, students can critically reflect on the ideals and realities of contemporary science. They will be able to address questions such as: How robust is scientific knowledge? What are the capabilities and limitations of predictive models? How effective is quality assurance in science, and how can it be improved? What types of questions can science answer, and what questions remain beyond its scope?

Subject area 2: Science in Society

This focuses on the interactions between science and different areas of society, such as how scientific knowledge influences social decision-making and how social demands impact scientific research. Students learn about the specific functional logics of various societal sectors and, based on this understanding, estimate where conflicts of goals and actions might arise in transfer processes—for example, between science and business, science and politics, or science and journalism. Typical questions in this subject area include: How and under what conditions does an innovation emerge from a scientific discovery? How does scientific policy advice work? How do business and politics influence science, and when is this problematic? According to which criteria do journalists incorporate scientific findings into media reporting? Where does hostility towards science originate, and how can social trust in science be strengthened?

After completing courses in the "Sciene in Society" area, students can understand and assess the goals and constraints of actors in different societal sectors. This equips them to adopt various perspectives of communication and action partners in transfer processes and to act competently at various social interfaces with research in their professional lives.

Subject area 3: Science in Public Debates

The courses in this subject area provide insights into current debates on major social issues such as sustainability, digitalization, artificial intelligence, gender equality, social justice, and educational opportunities. Public debates on complex challenges are often polarized, leading to oversimplifications, defamation, or ideological thinking. This can hinder effective social solution-finding processes and alienate people from the political process and from science. Debates about sustainable development are particularly affected, as they involve a wide range of scientific and technological knowledge in both problem diagnosis (e.g., loss of biodiversity, climate change, resource consumption) and solution development (e.g., nature conservation, CCS, circular economy).

By attending courses in "Science in Public Debates," students are trained in an application-oriented way to engage in factual debates—exchanging arguments, addressing their own prejudices, and handling contradictory information. They learn that factual debates can often be conducted more deeply and with more nuance than is often seen in public discourse. This training enables them to handle specific factual issues in their professional lives independently of their own biases and to be open to differentiated, fact-rich arguments.

Supplementary credits:

Additional LP (supplementary work) totalling a maximum of 12 LP can also be acquired from the complementary study programme (see statutes for the WTG complementary study programme § 7). § 4 and § 5 of the statutes remain unaffected by this. These supplementary credits are not included in the overall grade of the accompanying study programme. At the request of the participant, the supplementary work will be included in the certificate of the accompanying study programme and marked as such. Supplementary coursework is listed with the grades provided for in § 9.

Module Grade Calculation

The overall grade of the supplementary course is calculated as a credit-weighted average of the grades that were achieved in the advanced module.

Additional Information
Climate change, biodiversity crisis, antibiotic resistance, artificial intelligence, carbon capture and storage, and gene editing are just a few areas where science and technology can diagnose and address numerous social and global challenges. The extent to which scientific findings are considered in politics and society depends on various factors, such as public understanding and trust, perceived opportunities and risks, and ethical, social, or legal considerations.
To enable students to use their expertise as future decision-makers in solving social and global challenges, we aim to equip them with the skills to navigate the interfaces between science, business, and politics competently and reflectively. In the Supplementary Studies, they acquire foundational knowledge about the interactions between science, technology, and society.

They learn:
- How reliable scientific knowledge is produced,
- how social expectations and demands influence scientific research, and
- how scientific knowledge is adopted, discussed, and utilized by society.

The program integrates essential insights from psychology, philosophy, economics, social sciences, and cultural studies into these topics. After completing the supplementary studies programme, students can place the content of their specialized studies within a broader social context. This prepares them, as future decision-makers, to navigate competently and reflectively at the intersections between science and various sectors of society, such as politics, business, or journalism, and to contribute effectively to innovation processes, public debates, or political decision-making.

Workload
The workload is made up of the number of hours of the individual modules:

- Basic Module approx. 120 hours
- Advanced Module approx. 360 hours

> Total: approx. 480 hours

In the form of supplementary services, up to approximately 360 hours of work can be added.

Recommendations
It is recommended to complete the supplementary study program in three or more semesters, beginning with the lecture series on science, technology, and society in the summer semester. Alternatively, you can start with the basic seminar in the winter semester and then attend the lecture series in the summer semester.

Courses in the Advanced Module can be taken simultaneously. It is also advised to complete courses from each of the three subject areas in the advanced unit.

Teaching and Learning Methods
- Lectures
- Seminars/Project Seminars
- Workshops

M 2.210 Module: Technical Optics [M-ETIT-100538]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: Electrical Engineering / Information Technology (Electrical Engineering / Information Technology)

Credits	Grading	Recurrence	Duration	Language	Level	Version
5 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100804	Technical Optics	5 CP	Neumann

Prerequisites
none

2.211 Module: Technomathematical Seminar [M-MATH-102863]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Experimental Physics (mandatory)
Wildcard Technical Field
Electrical Engineering / Information Technology (mandatory)
Chemical and Process Engineering (mandatory)

Credits	Grading	Recurrence	Duration	Level	Version
3 CP	pass/fail	Each term	1 term	4	1

Mandatory			
T-MATH-105884	Technomathematical Seminar	3 CP	Jahnke, Kühnlein

Prerequisites
None

Competence Goal
At the end of the module, the participants can

- analyze a specific problem in a scientific area
- discuss, present and defend subject-specific problems in the given context
- summarize the most important results concerning the topic

They have communicative, organizational and didactical skills in complex problem analyses at their disposal. They can apply techniques of scientific work.

Content
The technomathematical seminar optionally can be completed in mathematics, in computer sciences or in the technical subject. The specific content depends on the offered seminar courses. The chosen topic must possess a significant connection to applications. Admissible are seminar talks of at least 45 minutes as in the other mathematical seminar courses as well as the treatment of small projects with a project report and short presentation at the end, for instance in the technical field.

Workload
Total work load: 90 minutes.

The specific workload in attendance and self studies depends on the specific choice.

M 2.212 Module: Telematics [M-INFO-107243]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	English	4	1

Mandatory			
T-INFO-114269	Telematics	6 CP	Zitterbart

Assessment
See partial achievements (Teilleistung)

Prerequisites
See partial achievements (Teilleistung)

Competence Goal
Students

- master protocols, architectures, and methods and algorithms that are used on the Internet for routing and for establishing a reliable end-to-end connection, as well as various media allocation procedures in local networks.
- have an understanding of the systems and the problems that appear in a global, dynamic network as well as the mechanisms used to remedy them.
- are familiar with current developments such as SDN and data center networking.
- know methods to manage and administrate networks.

Students master the basic protocol mechanisms for establishing reliable end-to-end communication. Students have detailed knowledge of the mechanisms used in TCP for congestion and flow control and can discuss the issue of fairness with multiple parallel transport streams. Students can analytically determine the performance of transport protocols and know methods that fulfill special requirements of TCP, such as high data rates and short latencies. Students are familiar with current topics such as problems introduced by utilization of middle boxes in the Internet, the use of TCP in data centers and multipath TCP. Students can use transport protocols in practice.

Students know the functions of routers in the Internet and can reproduce and apply common routing algorithms. Students can reproduce the architecture of a router and know different approaches to buffer placement as well as their advantages and disadvantages.

Students understand the distinction of routing protocols into interior and exterior gateway protocols and have detailed knowledge of the functionality and properties of common protocols such as RIP, OSPF and BGP. The students are familiar with current topics such as SDN.

Students know the function of media allocation and can classify and analytically evaluate media allocation processes. Students have in-depth knowledge of Ethernet and are familiar with various Ethernet forms and their differences, especially current developments such as real-time Ethernet and data center Ethernet. Students can reproduce and apply the spanning tree protocol.
Students can reproduce the technical characteristics of DSL. Students are familiar with the concept of label switching and can compare existing approaches such as MPLS.

Content

- Introduction
- End-to-end data transport
- Routing protocols and architectures
- Media allocation
- Bridges
- Data transmission
- Further selected examples
- Network management

Workload
Lecture with 3 SWS plus follow-up/exam preparation, 6 CP.
6 CP corresponds to approx. 180 working hours, of which
approx. 60 hours lecture attendance
approx. 60 hours preparation/follow-up work
approx. 60 hours exam preparation

M 2.213 Module: Theoretical Nanooptics [M-PHYS-102295]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-PHYS-104587	Theoretical Nanooptics	6 CP	Garst, Rockstuhl

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
The properties of light at the nanoscale can be controlled by various means. The aim of this lecture is to familiarize the students with the different possibilities that rely on nanostructured dielectric or metallic materials and to outline on solid mathematical grounds the analytical description of observable effects. The lecture is meant as a complementary source of education to experimental lecture. It shall provide the students with the necessary skills to work themselves in the field of theoretical nanooptics.

Content

- Dispersion relation to describe light in extended systems such as free space, interfaces, planar waveguides and waveguides with complicated geometrical cross sections.
- Description of the interaction of light with isolated objects such as spheres, cylinders, ellipsoids and prolates and oblates.
- Properties of plasmonic nanoparticles and the ability to tune their properties
- Notion of optical antennas and the discussion of their basic characteristics
- Description of the dynamics of wave propagation by perturbed eigenstates, i.e. coupled mode theory. Application to optical waveguide arrays.
- Discussion of metamaterials (unit cells, homogenization, light propagation, applications)
- Transformation optics
- Analytical modeling and phenomenological tools to describe nanooptical systems

Workload
180 hours composed of active time (45), wrap-up of the lecture incl. preparation of the examination and the excercises (135)

Recommendations
Solid mathematical background, good knowledge of classical electromagnetism and theoretical optics.

Literature

- L. Novotny and B. Hecht, Principle of Nano-Optics, Cambridge
- S. A. Maier, Plasmonics, Springer
- J. D. Joannopoulos, S. G. Johnson, J. N. Winn and R. D. Meade, Photonic Crystals: Molding the Flow of Light, University Press

M 2.214 Module: Theoretical Optics [M-PHYS-102277]

Responsible: PD Dr. Boris Narozhnyy
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: Experimental Physics (Experimental Physics)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104578	Theoretical Optics	6 CP	Narozhnyy, Rockstuhl

Assessment
Oral Exam. In the MSc Physics, this module is examined together with further modules attended as part of the major in physics. The total duration of the oral exam is approx. 60 minutes.

Prerequisites
none

Competence Goal
The students deepen their knowledge about the theory and the mathematical tools in optics and photonics. They learn how to apply these tools to describe fundamental phenomena and how to predict observable quantities that reflect the actual physics from the theory by way of a corresponding purposeful mathematical analyses. They learn how to solve problems of both, interpretative and predictive nature with regards to model systems and real life situations.

Content

- Review of Electromagnetism (Maxwell's Equations, Stress Tensor, Material Properties, Kramers-Kronig Relation, Wave Propagation, Poynting's Theorem)
- Diffraction Theory (The Principles of Huygens and Fresnel, Scalar Diffraction Theory: Green's Function, Helmholtz-Kirchhoff Theorem, Kirchhoff Formulation of Diffraction, Fresnel-Kirchhoff Diffraction Formula, Rayleigh-Sommerfeld Formulation of Diffraction, Angular Spectrum Method, Fresnel and Fraunhofer Diffraction, Method of Stationary Phases, Basics og Holography)
- Crystal Optics (Polarization, Anisotropic Media, Fresnel Equation, Applications)
- Classical Coherence Theory (Elementary Coherence Phenomena, Theory of Stochastic Processes, Correlation Functions)
- Quantum Optics and Quantum Optical Coherence Theory (Review of Quantum Mechanics, Quantization of the EM Field, Quantum Coherence Functions)

Additional Information
For students of the KIT Faculty of Computer Science: The exams in this module have to be registered via admissions from ISS (KIT Faculty of Computer Science). For this, an e-mail with matriculation numbers and name of the desired exam to Beratung-informatik@informatik.kit.edu is sufficient.

Workload
180 hours composed of active time (45 hours), wrap-up of the lecture incl. preparation of the examination (135 hours)

Recommendations
Solid mathematical background, good knowledge of classical electromagnetism and basic knowledge of quantum mechanics.

Literature

- "Classical Electrodynamics" John David Jackson
- "Theoretical Optics: An Introduction" Hartmann Römer
- "Introduction to Fourier Optics" Joseph W. Goodman
- "Introduction to the Theory of Coherence and Polarization of Light" Emil Wolf
- "The Quantum Theory of Light " Rodney Loudon

2.215 Module: Thermodynamics III [M-CIWVT-103058]

Responsible: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106033	Thermodynamics III	6 CP	Enders

Assessment
Learning control is a written examination lasting 90 minutes.

Prerequisites
None

Competence Goal
Students are familiar with the basic principles for the description of complex, multicomponent mixtures and thermodynamic equilibria including equilibria with chemical reactions. They are able to select suitable models and to calculate the properties of multicomponent real systems.

Content
Phase- and reaction equilibria of real systems, equations of state for real mixtures, models for activity coefficients, polymer solutions, protein solutions, elektrolyte solutions.

Module Grade Calculation
The module grade is the grade of the written exam.

Workload

- Attendance time (Lecture): 60 h
- Homework: 90 h
- Exam Preparation: 30 h

Literature

1. Stephan, P., Schaber, K., Stephan, K., Mayinger, F.: Thermodynamik, Band 2, 15. Auflage, Springer Verlag, 2010.
2. Sandler, S. I.: Chemical, Biochemical and Engineering Thermodynamics, J. Wiley & Sons, 2008.
3. Gmehling, J, Kolbe, B., Kleiber, M., Rarey, J.: Chemical Thermodynamics for Process Simulations, Wiley-VCG Verlag, 2012

M 2.216 Module: Thermodynamics of Interfaces [M-CIWVT-103063]

Responsible: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: Chemical and Process Engineering (Chemical and Process Engineering)

Credits	Grading	Recurrence	Duration	Language	Level	Version
4 CP	graded	Each summer term	1 term	German/English	4	1

Mandatory			
T-CIWVT-106100	Thermodynamics of Interfaces	4 CP	Enders

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

Competence Goal
The students to be familiar with the peculiarities on fluid-fluid and fluid-solid interfacial properties. They are able to calculate interfacial properties (interfacial tension, density - and concentration profils, adsorption isotherms) using macroscopic and local-dependent methods.

Content
Gibbs-method, density functional theory, experimental methods for characterization of interfaces, adsorption

Module Grade Calculation
The module grade is the grade of the oral exam.

Additional Information
If required, the course will be offered in English.

M 2.217 Module: Time Series Analysis [M-MATH-102911]

Responsible: PD Dr. Bernhard Klar
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Each summer term	1 term	4	3

Mandatory			
T-MATH-105874	Time Series Analysis	4 CP	Ebner, Fasen-Hartmann, Gneiting, Klar, Trabs

Assessment
The module will be completed by an oral exam (ca. 20 min).

Prerequisites
None

Competence Goal
At the end of the course, students will

- know and understand the standard models of time series analysis,
- know exemplary statistical methods for model selection and model validation,
- independently apply models and methods from the lecture to real and simulated data,
- know specific mathematical techniques and be able to use them to analyze time series models.

Content
The lecture covers the basic concepts of classical time series analysis:

- Stationary time series
- Trends and seasonality
- Autocorrelation
- Autoregressive models
- ARMA models
- Parameter estimation
- Forecasting
- Spectral density and periodogram

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 120 hours

Attendance: 45 hours

- lectures, problem classes, and examination

Self-studies: 75 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the course "Probability Theory" are strongly recommended. The contents of the course "Statistics" are recommended.

2.218 Module: Topics in Algebraic Topology [M-MATH-107017]

Responsible: TT-Prof. Dr. Manuel Krannich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-114063	Topics in Algebraic Topology	6 CP	Krannich

Assessment
The module examination takes the form of a written exam (120 min).

Prerequisites
none

Competence Goal
Students

- are able to calculate the discussed topological invariants in concrete examples;
- have mastered advanced techniques of algebraic topology;
- are able to work in a self-organized and reflective manner.

Content

- Examples of advanced invariants of algebraic topology (e.g. cohomology rings, higher homotopy groups)
- applications to the topology of manifolds (e.g. Poincaré duality)
- advanced homotopy theoretical concepts (e.g. fibrations and cofibrations, homotopy fibres)

Module Grade Calculation
The module grade is the grade of the written examination.

Workload
Total workload: 180 hours

Attendance time: 60 hours

- Course including module examination during the course of study

Self-study: 120 hours

- Deepening the study content by working on the lecture content at home
- completion of exercises
- In-depth study of the course content using suitable literature and internet research
- Preparation for the module examination during the course of study

Recommendations
The contents of the modules "Elementary Geometry" and "Algebraic Topology" are recommended.

M 2.219 Module: Topics in Homotopy Theory [M-MATH-107484]

Responsible: TT-Prof. Dr. Manuel Krannich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	1

Mandatory			
T-MATH-114682	Topics in Homotopy Theory	6 CP	Krannich

Assessment
The module examination takes the form of an oral examination (30 min.)

Prerequisites
None

Competence Goal
Graduates

- are able to calculate the homotopy-theoretic invariants discussed in concrete examples;
- are proficient in advanced techniques of homotopy theory;
- are able to work in a self-organized and reflective manner.

Content

- examples of advanced homotopy-theoretic invariants (e.g. cohomology operations, characteristic classes),
- advanced homotopy-theoretic concepts and methods (e.g. spectral sequences, spectra, obstruction theory, classification of fibrations and fiber bundles, Thom isomorphism),
- applications to the topology of manifolds (e.g. Wu formula, existence of exotic spheres)

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 180 hours

Attendance: 60 h

- lectures, problem classes and examination

Self studies: 120 h

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research on the course content,
- preparation for the module examination

Recommendations
The contents of the modules "Elementary Geometry", "Algebraic Topology" and "Topics in Algebraic Topology" are recommended.

M 2.220 Module: Topological Data Analysis [M-MATH-105487]

Responsible: Prof. Dr. Tobias Hartnick
Prof. Dr. Roman Sauer

Organisation: KIT Department of Mathematics

Part of: Applied Mathematics (Analysis)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
6 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-111031	Topological Data Analysis	6 CP	Hartnick, Sauer

M 2.221 Module: Translation Surfaces [M-MATH-105973]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
8 CP	graded	Irregular	1 term	German	4	1

Mandatory			
T-MATH-112128	Translation Surfaces	8 CP	Herrlich

Assessment
The module will be completed by an oral exam of about 30 min.

Prerequisites
None

Competence Goal
At the end of the module, participants are able to

- name and discuss basic concepts to study translation surfaces,
- describe and use in examples essential methods for the classification of translation surfaces,
- read recent research papers on translation surfaces and write a thesis in this field.

Content

- Chararcterization of finite translation surfaces
- Riemann surfaces and algebraic curves
- Moduli space of Riemann surfaces
- Classification of translation surfaces
- Strata and the action of SL(2,R)
- Period coordinates

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
Basic knowledge in surface topology and complex analysis is strongly recommended. The module "Algebraic Geometry" is also recommended.

M 2.222 Module: Traveling Waves [M-MATH-102927]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Language	Level	Version
6 CP	graded	Irregular	1 term	English	4	2

Mandatory			
T-MATH-105897	Traveling Waves	6 CP	de Rijk, Reichel

Assessment
The module examination takes place in form of an oral exam of about 30 minutes. Please see under "Modulnote" for more information about the bonus regulation.

Prerequisites
none

Competence Goal
After successful completion of this module students:

- can explain the significance of traveling waves and their dynamic stability;
- know basic methods to study the existence of traveling waves;
- outline the main steps in a stability analysis and address potential complications;
- have acquired several mathematical tools to compute or approximate the spectrum;
- master several techniques to derive (in)stability of the wave from spectral information;
- understand how spectrum and stability might depend on the class of perturbations.

Content
Traveling waves are solutions to nonlinear partial differential equations (PDEs) that propagate over time with a fixed speed without changing their profiles. These special solutions arise in many applied problems where they model, for instance, water waves, nerve impulses in axons or light in optical fibers. Therefore, their existence and the naturally associated question of their dynamic stability is of interest, because only those waves which are stable can be observed in practice.

The first step in the stability analysis is to linearize the underlying PDE about the wave and compute the associated spectrum, which is in general a nontrivial task. To approximate spectra associated with various waves, such as fronts, pulses and periodic wave trains, we introduce the following tools:

- Sturm-Liouville theory
- exponential dichotomies
- Fredholm theory
- the Evans function
- parity arguments
- essential spectrum, point spectrum and absolute spectrum
- exponential weights

The next step is to derive useful bounds on the linear solution operator, or semigroup, based on the spectral information. A complicating factor is that any non-constant traveling wave possesses spectrum up to the imaginary axis. For various dissipative PDEs, such as reaction-diffusion systems, we employ the bounds on the linear solution operator to close a nonlinear argument via iterative estimates on the Duhamel formula. For traveling waves in Hamiltonian PDEs, such as the NLS or KdV equation, we describe a different route towards stability based on the variational arguments of Grillakis, Shatah and Strauss.

Module Grade Calculation
After passing the oral exam at the end of the semester, the final grade is min(0.7X + 0.3Y, X), where X is the grade for the oral exam and Y is the grade obtained by voluntarily working out and presenting a model problem during one of the exercise classes.

Workload
Total workload: 180 hours

Attendance: 60 hours

- lectures, problem classes, and examination

Self-studies: 120 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The following background is strongly reommended: Analysis 1-4.

Literature
Kapitula, Todd; Promislow, Keith. Spectral and dynamical stability of nonlinear waves. Applied Mathematical Sciences, 185. Springer, New York, 2013.

M 2.223 Module: Uncertainty Quantification [M-MATH-104054]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
4 CP	graded	Each summer term	1 term	4	1

Mandatory			
T-MATH-108399	Uncertainty Quantification	4 CP	Frank

Prerequisites
None

Competence Goal
After successfully taking part in the module's classes and exams, students have gained knowledge and abilities as described in the "Inhalt" section.

Specifically, students know several parametrization methods for uncertainties. Furthermore, students are able to describe the basics of several solution methods (stochastic collocation, stochastic Galerkin, Monte-Carlo). Students can explain the so-called curse of dimensionality.

Students are able to apply numerical methods to solve engineering problems formulated as algebraic or differential equations with uncertainties. They can name the advantages and disadvantages of each method. Students can judge whether specific methods are applicable to the specific problem and discuss their results with specialists and colleagues. Finally, students are able to implement the above methods in computer codes.

Content
In this class, we learn to propagate uncertain input parameters through differential equation models, a field called Uncertainty Quantification (UQ). Given uncertain input (parameter values, initial or boundary conditions), how uncertain is the output? The first part of the course ("how to do it") gives an overview on techniques that are used. Among these are:

- Sensitivity analysis
- Monte-Carlo methods
- Spectral expansions
- Stochastic Galerkin method
- Collocation methods, sparse grids

The second part of the course ("why to do it like this") deals with the theoretical foundations of these methods. The so-called "curse of dimensionality" leads us to questions from approximation theory. We look back at the very standard numerical algorithms of interpolation and quadrature, and ask how they perform in many dimensions.

Recommendations
Numerical methods for differential equations

2.224 Module: Variational Methods [M-MATH-105093]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Analysis)
Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-110302	Variational Methods	8 CP	Reichel

Assessment
The module will be completed by an oral exam (ca. 30 min).

Competence Goal
Graduates will be able to

- assess the significance of variational problems in relation to their applications in the natural sciences, engineering or geometry and illustrate them using examples,
- formulate variational problems independently,
- recognize the specific difficulties within the calculus of variations,
- analyze and solve concrete, prototypical problems,
- use techniques to prove the existence of solutions to certain classes of variational problems and calculate these solutions in special cases.

Content

- one-dimensional variational problems
- Euler-Lagrange equation
- necessary and sufficient criteria
- multidimensional variational problems
- direct methods of the calculus of variations
- existence of critical points of functionals

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The contents of the courses Functional Analysis, Classical Methods for Partial Differential Equations, or Boundary and Eigenvalue problems are recommended.

2.225 Module: Wavelets [M-MATH-102895]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading	Recurrence	Duration	Level	Version
8 CP	graded	Irregular	1 term	4	1

Mandatory			
T-MATH-105838	Wavelets	8 CP	Rieder

Assessment
Success is assessed in the form of an oral examination lasting approx. 30 minutes.

Prerequisites
none

Competence Goal
Graduates are able

- to name, discuss and analyze the functional-analytical principles of continuous and discrete wavelet transforms,
- to apply the wavelet transform as an analysis tool in signal and image processing and evaluate the results obtained,
- to explain design aspects for wavelet systems.

Content

- Short-time Fourier transform
- Integral wavelet transform
- Wavelet frames
- Wavelet basis
- Fast wavelet transform
- Construction of orthogonal and bi-orthogonal wavelet systems
- Applications in signal and image processing

Module Grade Calculation
The module grade is the grade of the oral exam.

Workload
Total workload: 240 hours

Attendance: 90 hours

- lectures, problem classes, and examination

Self-studies: 150 hours

- follow-up and deepening of the course content,
- work on problem sheets,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendations
The course "Functional analysis" is recommended.

3 Courses

T 3.1 Course: Adaptive Finite Element Methods [T-MATH-105898]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: M-MATH-102900 - Adaptive Finite Elemente Methods

Type	Credits	Grading	Version
Oral examination	8 CP	graded	2

Events					
ST 2025	0159610	Adaptive Finite Elemente Methods	4 SWS	Lecture	Dörfler
ST 2025	0159620	Tutorial for 0159610 (adaptive Finite Elemente Methods)	2 SWS	Practice	Dörfler

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Recommendations
Basic knowledge of finite element methods, a programming language and the analysis of boundary value problems is strongly recommended. Knowledge of functional analysis is recommended.

Workload
240 hours

Below you will find excerpts from events related to this course:

V Adaptive Finite Elemente Methods
0159610, SS 2025, 4 SWS, Open in study portal

Lecture (V)

Content
The Finite Element Method is the method of choice for the solution of elliptic boundary value problems. In computing these approximations we follow two aims: We need a computable error bound to judge the quality of an approximation, and we want to reduce the amount of work to obtain an approximation of a prescribed tolerance. The first aim is a must since numerical simulations without information about their accuracy may be not reliable. This has been seen by some failures in the past, see information about the Sleipner accident. The second aim may be achieved by constructing local (e.g.\ in space) error indicators and perform local refinement where large errors are indicated. We show for a model problem how to construct convergent local refinement algorithms and show that the algorithm has optimal complexity.

T 3.2 Course: Advanced Inverse Problems: Nonlinearity and Banach Spaces [T-MATH-105927]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102955 - Advanced Inverse Problems: Nonlinearity and Banach Spaces

Type	Credits	Grading	Version
Oral examination	5 CP	graded	1

Prerequisites
none

T 3.3 Course: Advanced Methods in Nonlinear Partial Differential Equations [T-MATH-113691]

Responsible: Dr. Björn de Rijk
Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-106822 - Advanced Methods in Nonlinear Partial Differential Equations

Type	Credits	Grading	Version
Oral examination	3 CP	graded	1

Assessment
The module examination takes place in form of an oral exam of about 30 minutes.

Prerequisites
none

Recommendations
The following modules are recommended: Analysis 1-3, Functional Analysis, Evolution Equations.

Workload
90 hours

T 3.4 Course: Algebra [T-MATH-102253]

Responsible: PD Dr. Stefan Kühnlein
Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: M-MATH-101315 - Algebra

Type	Credits	Grading	Version
Oral examination	8 CP	graded	2

Events					
WT 25/26	0102200	Algebra	4 SWS	Lecture / 🗣	Kühnlein
WT 25/26	0102210	Tutorial for 0102200 (Algebra)	2 SWS	Practice / 🗣	Kühnlein
Exams					
ST 2025	7700066	Algebra			Sauer, Kühnlein
ST 2025	7700144	Algebra			Sauer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.5 Course: Algebraic Geometry [T-MATH-103340]

Responsible: Prof. Dr. Frank Herrlich
PD Dr. Stefan Kühnlein

Organisation: KIT Department of Mathematics

Part of: M-MATH-101724 - Algebraic Geometry

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.6 Course: Algebraic Number Theory [T-MATH-103346]

Responsible: Prof. Dr. Frank Herrlich
PD Dr. Stefan Kühnlein

Organisation: KIT Department of Mathematics

Part of: M-MATH-101725 - Algebraic Number Theory

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Exams			
ST 2025	7700152	Algebraic Number Theory	Herrlich

Assessment
oral examination of ca. 30 minutes

Prerequisites
none

Workload
240 hours

3.7 Course: Algebraic Topology [T-MATH-105915]

Responsible: TT-Prof. Dr. Manuel Krannich
Jun.-Prof. Dr. Claudio Llosa Isenrich
Prof. Dr. Roman Sauer

Organisation: KIT Department of Mathematics

Part of: M-MATH-102948 - Algebraic Topology

Type	Credits	Grading	Version
Written examination	8 CP	graded	1

Exams			
ST 2025	7700134	Algebraic Topology	Krannich

Prerequisites
none

T 3.8 Course: Algebraic Topology II [T-MATH-105926]

Responsible: TT-Prof. Dr. Manuel Krannich
Prof. Dr. Roman Sauer

Organisation: KIT Department of Mathematics

Part of: M-MATH-102953 - Algebraic Topology II

Type	Credits	Grading	Recurrence	Version
Written examination	8 CP	graded	Irregular	1

Prerequisites
none

T 3.9 Course: Analytical and Numerical Homogenization [T-MATH-111272]

Responsible: Prof. Dr. Marlis Hochbruck
TT-Prof. Dr. Roland Maier

Organisation: KIT Department of Mathematics

Part of: M-MATH-105636 - Analytical and Numerical Homogenization

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Events					
ST 2025	0165700	Analytical and Numerical Homogenization	3 SWS	Lecture	Maier

Prerequisites
none

Below you will find excerpts from events related to this course:

V Analytical and Numerical Homogenization

0165700, SS 2025, 3 SWS, Open in study portal

Lecture (V)

Content
The objective of this lecture is to give an introduction to multiscale problems and (some) analytical and numerical homogenization techniques. Since a lot of research work has been dedicated to the field in recent years, not all aspects can be covered within this lecture. Nevertheless, the goal is to become familiar with general questions and ideas in the field of (elliptic) multiscale problems and corresponding methods. Specifically, we will cover

- a one-dimensional introduction to the overall questions and problems related to multiscale problems and homogenization
- general concepts of convergence
- the Heterogeneous Multiscale Method
- the Localized Orthogonal Decomposition method

Some (basic) knowledge on finite element methods and functional analysis is helpful for the lecture but not required.

T 3.10 Course: Applications of Topological Data Analysis [T-MATH-111290]

Responsible: Dr. Andreas Ott
Organisation: KIT Department of Mathematics
Part of: M-MATH-105651 - Applications of Topological Data Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites
none

T 3.11 Course: Aspects of Geometric Analysis [T-MATH-106461]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-103251 - Aspects of Geometric Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Events					
ST 2025	0176600	AG Geometrische Analysis	2 SWS	Seminar	Lamm

Prerequisites
Keine

T 3.12 Course: Astroparticle Physics I [T-PHYS-102432]

Responsible: Prof. Dr. Guido Drexlin
Prof. Dr. Kathrin Valerius
Organisation: KIT Department of Physics
Part of: M-PHYS-102075 - Astroparticle Physics I

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	4022011	Astroparticle Physics I: Dark Matter	3 SWS	Lecture / 🗣	Valerius, Biondi, Schlösser
WT 25/26	4022012	Exercises to Astroparticle Physics I: Dark Matter	1 SWS	Practice / 🗣	Valerius, NN

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.13 Course: Banach Algebras [T-MATH-105886]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: M-MATH-102913 - Banach Algebras

Type	Credits	Grading	Version
Oral examination	3 CP	graded	1

Prerequisites
none

Workload
90 hours

T 3.14 Course: Basic Seminar Supplementary Studies on Science, Technology and Society - Self Registration [T-FORUM-113579]

Responsible: Dr. Christine Mielke
Christine Myglas
Organisation: General Studies. Forum Science and Society (FORUM)
Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading	Recurrence	Expansion	Version
Coursework	2 CP	pass/fail	Each summer term	1 terms	1

Assessment
Study achievement in the form of a presentation or a term paper or project work in the selected course.

Prerequisites
None

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendations
It is recommended that the basic seminar be completed during the same semester as the lecture series "Science in Society". If it is not possible to attend the lecture series and the basic seminar in the same semester, the basic seminar can also be attended in the semesters before the lecture series.
However, attending courses in the advanced unit before attending the basic seminar should be avoided.

T 3.15 Course: Basics of Nanotechnology I [T-PHYS-102529]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: M-PHYS-102097 - Basics of Nanotechnology I

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Events					
WT 25/26	4021041	Basics of Nanotechnology I	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

3.16 Course: Basics of Nanotechnology II [T-PHYS-102531]

Responsible: apl. Prof. Dr. Gernot Goll
Organisation: KIT Department of Physics
Part of: M-PHYS-102100 - Basics of Nanotechnology II

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Events					
ST 2025	4021151	Basics of Nanotechnology II	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

3.17 Course: Batteries, Fuel Cells, and Electrolysis [T-ETIT-113986]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-107005 - Batteries, Fuel Cells, and Electrolysis

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	2

Events					
WT 25/26	2304240	Batteries, Fuel Cells and Electrolysis	2 SWS	Lecture / Blended	Krewer
WT 25/26	2304241	Practical Exercise to 2304240 Batteries, Fuel Cells and Electrolysis	2 SWS	Practice / Blended	Krewer, Sonder
Exams					
WT 25/26	7304240	Batteries, Fuel Cells, and Electrolysis			Krewer

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Assessment
Success control takes place in the form of a written examination lasting 120 minutes.

Prerequisites
The following partial achievements must not have started:

- T-ETIT-100983 - Batterien und Brennstoffzellen
- T-ETIT-114097 - Batterien, Brennstoffzellen und ihre Systeme

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-ETIT-100983 - Batteries and Fuel Cells must not have been started.

Below you will find excerpts from events related to this course:

V Batteries, Fuel Cells and Electrolysis
2304240, WS 25/26, 2 SWS, Language: English, Open in study portal

Lecture (V)
Blended (On-Site/Online)

Content
Batteries, fuel cells and electrolysis used in innovative energy and environmental technology applications will be covered. The course is divided into three sections. Firstly, the basics of thermodynamics, electrochemistry and the lossy mass transport processes involved in energy conversion are discussed. The second section deals with the structure and functional principle of fuel cells and electrolysis, and presents the most important approaches to electrical characterization and modelling. Applications in mobile and stationary systems in transportation and energy technology are discussed. The third section deals with electrochemical energy storage systems, with a focus on high-performance batteries for electric traction. Developments to increase energy density and power density are presented here, as well as the electrical characterization and modelling of batteries.

Organizational issues
Dates: 28.10.2025 - 17.02.2026
ILIAS

V

Practical Exercise to 2304240 Batteries, Fuel Cells and Electrolysis
2304241, WS 25/26, 2 SWS, Language: English, Open in study portal

Practice (Ü)
Blended (On-Site/Online)

Content

Batteries, fuel cells and electrolysis used in innovative energy and environmental technology applications will be covered. The course is divided into three sections. Firstly, the basics of thermodynamics, electrochemistry and the lossy mass transport processes involved in energy conversion are discussed. The second section deals with the structure and functional principle of fuel cells and electrolysis, and presents the most important approaches to electrical characterization and modelling. Applications in mobile and stationary systems in transportation and energy technology are discussed. The third section deals with electrochemical energy storage systems, with a focus on high-performance batteries for electric traction. Developments to increase energy density and power density are presented here, as well as the electrical characterization and modelling of batteries.

Organizational issues

Dates:

30.10.2025

13.11.2025

27.11.2025

11.12.2025

08.01.2026

22.01.2026

05.02.2026

19.02.2026

ILIAS

T 3.18 Course: Bayesian Inverse Problems with Connections to Machine Learning [T-MATH-112842]

Responsible: Prof. Dr. Sebastian Krumscheid
Organisation: KIT Department of Mathematics
Part of: M-MATH-106328 - Bayesian Inverse Problems with Connections to Machine Learning

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	4 CP	graded	Each summer term	1 terms	1

Exams			
ST 2025	7700131	Bayesian Inverse Problems with Connections to Machine Learning	Krumscheid

Assessment
oral exam of ca. 30 min

Prerequisites
none

Workload
120 hours

T 3.19 Course: Bifurcation Theory [T-MATH-106487]

Responsible: Dr. Rainer Mandel
Organisation: KIT Department of Mathematics
Part of: M-MATH-103259 - Bifurcation Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	5 CP	graded	Irregular	1

Prerequisites
None

T 3.20 Course: Biopharmaceutical Purification Processes [T-CIWVT-106029]

Responsible: Prof. Dr. Jürgen Hubbuch
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103065 - Biopharmaceutical Purification Processes

Type	Credits	Grading	Version
Written examination	6 CP	graded	1

Events					
WT 25/26	2214010	Biopharmaceutical Purification Processes	3 SWS	Lecture / 🗣	Hubbuch, Franzreb
WT 25/26	2214011	Exercises on 2214010 Biopharmaceutical Purification Processes	1 SWS	Practice / 🗣	Hubbuch, Franzreb
Exams					
ST 2025	7223011	Biopharmaceutical Purification Processes			Hubbuch

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination is a written examination with a duration of 120 minutes (section 4 subsection 2 number 1 SPO).

T 3.21 Course: Bott Periodicity [T-MATH-108905]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-104349 - Bott Periodicity

Type	Credits	Grading	Recurrence	Version
Oral examination	5 CP	graded	Irregular	1

Prerequisites
none

T 3.22 Course: Boundary and Eigenvalue Problems [T-MATH-105833]

Responsible: Prof. Dr. Dorothee Frey
Prof. Dr. Dirk Hundertmark
Prof. Dr. Tobias Lamm
Prof. Dr. Michael Plum
Prof. Dr. Wolfgang Reichel
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: M-MATH-102871 - Boundary and Eigenvalue Problems

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
ST 2025	0157500	Boundary and Eigenvalue Problems	4 SWS	Lecture	Reichel
ST 2025	0157510	Tutorial for 0157500 (Boundary and Eigenvalue Problems)	2 SWS	Practice	Reichel
Exams					
ST 2025	7700062	Boundary and Eigenvalue Problems			Reichel, Liao, Lamm, Hundertmark

Below you will find excerpts from events related to this course:

V Boundary and Eigenvalue Problems

0157500, SS 2025, 4 SWS, Open in study portal

Lecture (V)

Content

We consider boundary value and eigenvalue problems within mathematics and physics, describe qualitative properties of solutions, prove the existence of solutions to boundary value problems using functional analytical methods and will work in more general function spaces, e.g. Sobolev spaces. Further contents are the weak formulation of 2nd order linear elliptic equations, existence and regularity theory of elliptic equations, as well as, eigenvalue theory for weakly formulated elliptic eigenvalue problems.

T 3.23 Course: Boundary Element Methods [T-MATH-109851]

Responsible: PD Dr. Tilo Arens
Organisation: KIT Department of Mathematics
Part of: M-MATH-103540 - Boundary Element Methods

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Prerequisites
none

T 3.24 Course: Boundary Value Problems for Nonlinear Differential Equations [T-MATH-105847]

Responsible: Prof. Dr. Michael Plum
Prof. Dr. Wolfgang Reichel

Organisation: KIT Department of Mathematics

Part of: M-MATH-102876 - Boundary value problems for nonlinear differential equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

3.25 Course: Brownian Motion [T-MATH-105868]

Responsible: Prof. Dr. Nicole Bäuerle
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Günter Last
Organisation: KIT Department of Mathematics
Part of: M-MATH-102904 - Brownian Motion

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Events					
WT 25/26	0155700	Brownsche Bewegung	2 SWS	Lecture	Last
WT 25/26	0155710	Übungen zu 0155700 (Brownsche Bewegung)	1 SWS	Practice	Last

Prerequisites
none

Workload
120 hours

3.26 Course: Class Field Theory [T-MATH-114500]

Responsible: Prof. Dr. Frank Herrlich
PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: M-MATH-107387 - Class Field Theory

Type	Credits	Grading	Expansion	Version
Oral examination	8 CP	graded	1 terms	1

Assessment
The module examination takes the form of an oral examination lasting approx. 30 minutes.

Prerequisites
none

Workload
240 hours

T 3.27 Course: Classical Methods for Partial Differential Equations [T-MATH-105832]

Responsible: Prof. Dr. Dorothee Frey
Prof. Dr. Dirk Hundertmark
Prof. Dr. Tobias Lamm
Prof. Dr. Michael Plum
Prof. Dr. Wolfgang Reichel
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: M-MATH-102870 - Classical Methods for Partial Differential Equations

Type	Credits	Grading	Version
Written examination	8 CP	graded	1

Events					
WT 25/26	0105300	Classical Methods for Partial Differential Equations	4 SWS	Lecture	
WT 25/26	0105310	Tutorial for 0105300 (Classical Methods for Partial Differential Equations)	2 SWS	Practice	
Exams					
ST 2025	7700052	Classical Methods for Partial Differential Equations			Reichel, Liao, Hundertmark, Zillinger, Tolksdorf

T 3.28 Course: Cognitive Systems [T-INFO-101356]

Responsible: Prof. Dr. Gerhard Neumann
Prof. Dr. Alexander Waibel

Organisation: KIT Department of Informatics

Part of: M-INFO-100819 - Cognitive Systems

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

T 3.29 Course: Combinatorics [T-MATH-105916]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-102950 - Combinatorics

Type	Credits	Grading	Version
Written examination	8 CP	graded	3

Prerequisites
none

T 3.30 Course: Combustion Technology [T-CIWVT-106104]

Responsible: Prof. Dr.-Ing. Dimosthenis Trimis
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103069 - Combustion Technology

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2232010	Fundamentals of Combustion Technology	2 SWS	Lecture / 🗣	Trimis
WT 25/26	2232011	Exercises for 2232010 Fundamentals of Combustion Technology	1 SWS	Practice / 🗣	Trimis, und Mitarbeitende
Exams					
ST 2025	7231201	Combustion Technology			Trimis

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 3.31 Course: Complex Analysis [T-MATH-105849]

Responsible: PD Dr. Gerd Herzog
Prof. Dr. Michael Plum
Prof. Dr. Wolfgang Reichel
Prof. Dr. Roland Schnaubelt
Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of: M-MATH-102878 - Complex Analysis

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

3.32 Course: Complex Geometry [T-MATH-113614]

Responsible: Jun.-Prof. Dr. Claudio Llosa Isenrich
Organisation: KIT Department of Mathematics
Part of: M-MATH-106776 - Complex Geometry

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Assessment
oral exam (ca. 30 min)

Prerequisites
none

Workload
180 hours

T 3.33 Course: Compressive Sensing [T-MATH-105894]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102935 - Compressive Sensing

Type	Credits	Grading	Recurrence	Version
Oral examination	5 CP	graded	Irregular	1

T 3.34 Course: Computational Fluid Dynamics [T-CIWVT-106035]

Responsible: Prof. Dr.-Ing. Hermann Nirschl
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103072 - Computational Fluid Dynamics

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each term	1

Events					
WT 25/26	2245020	Computational Fluid Dynamics	2 SWS	Lecture / 🗣	Nirschl, und Mitarbeitende
WT 25/26	2245021	Exercises for 2245020 Computational Fluid Dynamics	1 SWS	Practice / 🗣	Nirschl, und Mitarbeitende
Exams					
ST 2025	7291932	Computational Fluid Dynamics			Nirschl

Legend: 🖥 Online, ❁ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is a written examination lasting 90 minutes.

Prerequisites
None

T 3.35 Course: Computational Fluid Dynamics and Simulation Lab [T-MATH-113373]

Responsible: Prof. Dr. Martin Frank
PD Dr. Mathias Krause
Dr. Stephan Simonis
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: M-MATH-106634 - Computational Fluid Dynamics and Simulation Lab

Type	Credits	Grading	Version
Examination of another type	4 CP	graded	1

Events					
ST 2025	0161700	Computational Fluid Dynamics and Simulation Lab	4 SWS	Practical course	Thäter, Krause, Simonis
Exams					
ST 2025	7700126	Computational Fluid Dynamics and Simulation Lab			Thäter

Prerequisites
none

Workload
120 hours

Below you will find excerpts from events related to this course:

V Computational Fluid Dynamics and Simulation Lab

0161700, SS 2025, 4 SWS, Language: German/English, Open in study portal

Practical course (P)

Content
The course is held in two parts. The lecture part contains introductions to modeling and simulations, to associated numerical methods, and to associated software and high-performance computer hardware, respectively. The second part is based on supervised group work of the students. Participants work on projects in which modelling, discretization, simulation and evaluation (e.g. visualization) are carried out for specific topics from the catalog. The catalog includes e.g: Diffusion processes, turbulent flows, multiphase flows, reactive flows, particle dynamics, optimal control and optimization under constraints, stabilization methods for advection-dominated transport problems.

At the end of the course, the students are able to jointly model problems beyond their own discipline and simulate them on high-performance computers. They have acquired a critical distance to results and their presentation. They can defend the results of projects in disputes. They have understood the importance of stability, convergence and parallelism of numerical methods from their own experience and are able to evaluate errors in modeling, approximation, computing and presentation.

Basic knowledge of the analysis of boundary value problems and of numerical methods for differential equations is recommended. Knowledge of a programming language is strongly recommened.

T 3.36 Course: Computer Architecture [T-INFO-101355]

Responsible: Prof. Dr. Wolfgang Karl
Organisation: KIT Department of Informatics
Part of: M-INFO-100818 - Computer Architecture

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2424570	Computer structures	3 SWS	Lecture / 🗣	Karl
Exams					
ST 2025	7500190	Computer Architecture			Karl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.37 Course: Computer Graphics [T-INFO-101393]

Responsible: Prof. Dr.-Ing. Carsten Dachsbacher
Organisation: KIT Department of Informatics
Part of: M-INFO-100856 - Computer Graphics

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2424081	Computergraphics	4 SWS	Lecture / 🗣	Dachsbacher, Alber, Lerzer
Exams					
ST 2025	7500257	Computer Graphics			Dachsbacher

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.38 Course: Computer Graphics Pass [T-INFO-104313]

Responsible: Prof. Dr.-Ing. Carsten Dachsbacher
Organisation: KIT Department of Informatics
Part of: M-INFO-100856 - Computer Graphics

Type	Credits	Grading	Recurrence	Version
Coursework	0 CP	pass/fail	Each winter term	1

Events					
WT 25/26	2424083	Übungen zu Computergrafik		Lecture / Practice (/ 🗣	Alber, Lerzer, Dachsbacher

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.39 Course: Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems [T-MATH-105854]

Responsible: Prof. Dr. Michael Plum
Organisation: KIT Department of Mathematics
Part of: M-MATH-102883 - Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.40 Course: Condensed Matter Theory I, Fundamentals [T-PHYS-102559]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102054 - Condensed Matter Theory I, Fundamentals

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Each winter term	1

Events					
WT 25/26	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Shnirman
WT 25/26	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Shnirman, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.41 Course: Condensed Matter Theory I, Fundamentals and Advanced Topics [T-PHYS-102558]

Responsible: PD Dr. Robert Eder
Prof. Dr. Markus Garst
Prof. Dr. Alexander Mirlin
Prof. Dr. Alexander Shnirman

Organisation: KIT Department of Physics

Part of: M-PHYS-102053 - Condensed Matter Theory I, Fundamentals and Advanced Topics

Type	Credits	Grading	Recurrence	Version
Oral examination	12 CP	graded	Each winter term	1

Events					
WT 25/26	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Shnirman
WT 25/26	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Shnirman, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

3.42 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals [T-PHYS-104591]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Mathematics
KIT Department of Physics

Part of: M-PHYS-102313 - Condensed Matter Theory II: Many-Body Theory, Fundamentals

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.43 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics [T-PHYS-102560]

Responsible: Prof. Dr. Markus Garst
apl. Prof. Dr. Igor Gornyi
Prof. Dr. Alexander Mirlin
PD Dr. Boris Narozhnyy
Prof. Dr. Jörg Schmalian

Organisation: KIT Department of Physics

Part of: M-PHYS-102308 - Condensed Matter Theory II: Many-Body Theory, Fundamentals and Advanced Topics

Type	Credits	Grading	Version
Oral examination	12 CP	graded	1

Events					
ST 2025	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Mirlin, Poboiko
ST 2025	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Mirlin, Poboiko, Scoquart

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.44 Course: Continuous Time Finance [T-MATH-105930]

Responsible: Prof. Dr. Nicole Bäuerle
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102860 - Continuous Time Finance

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
ST 2025	0159400	Continuous Time Finance	4 SWS	Lecture	Fasen-Hartmann
ST 2025	0159410	Tutorial for 0159400 (Continuous Time Finance)	2 SWS	Practice	Fasen-Hartmann
Exams					
ST 2025	7700110	Continuous Time Finance			Fasen-Hartmann
ST 2025	7700112	Continuous Time Finance			Fasen-Hartmann

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Workload
240 hours

Below you will find excerpts from events related to this course:

V Continuous Time Finance
0159400, SS 2025, 4 SWS, Open in study portal

Lecture (V)

Content
The lecture covers central topics in continuous-time finance. The first part of the course is an introduction to stochastic analysis. First, we introduce Brownian motion and important topics in the theory of martingales. We then develop the stochastic integral and describe its importance in finance. The second part of the course focuses on the analysis of the Black-Scholes model where the asset process is modelled by a geometric Brownian motion. In this market we price and hedge options. We derive the first and second fundamental theorems of asset pricing, which describe the relationships between arbitrage freedom, equivalent martingale measures and completeness. Finally, we study portfolio optimisation problems and term structure models.

Topics:

- Stochastic processes
- Total variation and quadratic variation
- Ito integral
- Black-Scholes model
- Bonds, futures, term structure models

T 3.45 Course: Control Theory [T-MATH-105909]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: M-MATH-102941 - Control Theory

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Prerequisites
none

T 3.46 Course: Convex Geometry [T-MATH-105831]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: M-MATH-102864 - Convex Geometry

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

3.47 Course: Curves on Surfaces [T-MATH-113364]

Responsible: Dr. Elia Fioravanti
Organisation: KIT Department of Mathematics
Part of: M-MATH-106632 - Curves on Surfaces

Type	Credits	Grading	Recurrence	Version
Oral examination	3 CP	graded	Irregular	1

Assessment
oral exam (ca. 20-30 min)

Prerequisites
none

Workload
90 hours

T 3.48 Course: Deep Learning and Neural Networks [T-INFO-114219]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: M-INFO-107197 - Deep Learning and Neural Networks

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2400024	Deep Learning and Neural Networks	4 SWS	Lecture / 🗣	Niehues
Exams					
ST 2025	7500044	Deep Learning and Neural Networks			Niehues, Waibel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
T-INFO-101383 - Neural networks must not be started.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-101383 - Neural Networks must not have been started.
2. The course T-INFO-109124 - Deep Learning and Neural Networks must not have been started.

Recommendations
Prior successful completion of the core module "Cognitive Systems" is recommended.

T 3.49 Course: Differential Geometry [T-MATH-102275]

Responsible: Prof. Dr. Alexander Lytchak
Prof. Dr. Wilderich Tuschmann

Organisation: KIT Department of Mathematics

Part of: M-MATH-101317 - Differential Geometry

Type	Credits	Grading	Version
Written examination	8 CP	graded	1

Events					
ST 2025	0100300	Differential Geometry	4 SWS	Lecture	Lytchak
ST 2025	0100310	Tutorial for 0100300 (Differential Geometry)	2 SWS	Practice	Lytchak
Exams					
ST 2025	7700033	Differential Geometry - Exam			Tuschmann, Lytchak

Below you will find excerpts from events related to this course:

V Differential Geometry

0100300, SS 2025, 4 SWS, Language: English, Open in study portal

Lecture (V)

Content

This course is an introduction to modern differential geometry. Differential geometry is the study of geometry of spaces using analytic and linear algebraic methods. After laying down the foundational definitions and basic properties of *smooth manifolds, tangent vectors*, and *Riemannian metrics*, we will develop notions of *linear connections* and *covariant derivatives* allowing us to do differential calculus on these manifolds. We will continue our journey of understanding the shape of these manifolds by developing concepts of *curvature tensors, geodesics, parallel transport* and *Jacobi fields*. We will also cover the celebrated *Bonnet-Myers* and *Cartan-Hadamard theorems* which show us that curvature conditions on a manifold can to some extent dictate the geometry and topology of the manifold.

T 3.50 Course: Discrete Dynamical Systems [T-MATH-110952]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: M-MATH-105432 - Discrete Dynamical Systems

Type	Credits	Grading	Recurrence	Version
Oral examination	3 CP	graded	Irregular	1

Events					
ST 2025	0106450	Diskrete dynamische Systeme	2 SWS	Lecture / 🗣	Herzog
Exams					
ST 2025	7700002	Discrete Dynamical Systems			Herzog

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

Workload
90 hours

T 3.51 Course: Discrete Time Finance [T-MATH-105839]

Responsible: Prof. Dr. Nicole Bäuerle
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102919 - Discrete Time Finance

Type	Credits	Grading	Recurrence	Version
Written examination	8 CP	graded	Each winter term	1

Events					
WT 25/26	0108400	Finanzmathematik in diskreter Zeit	4 SWS	Lecture / 🗣	Bäuerle
WT 25/26	0108500	Übungen zu 0108400 (Finanzmathematik in diskreter Zeit)	2 SWS	Practice / 🗣	Bäuerle

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Written exam of 2h.

Prerequisites
none

Recommendations
The contents of the module „Probability theory“ are strongly recommended.

Workload
240 hours

T 3.52 Course: Dispersive Equations [T-MATH-109001]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-104425 - Dispersive Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

T 3.53 Course: Dynamical Systems [T-MATH-106114]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-103080 - Dynamical Systems

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Prerequisites
none

T 3.54 Course: Elective Specialization Supplementary Studies on Science, Technology and Society / About Knowledge and Science - Self-Registration [T-FORUM-113580]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation: General Studies. Forum Science and Society (FORUM)

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading	Recurrence	Version
Examination of another type	3 CP	graded	Each term	1

Assessment
Another type of examination assessment under § 5, section 3 involves a presentation, term paper, or project work within the chosen course.

Prerequisites
None

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendations
The contents of the basic module are helpful. The basic module should be completed or attended in parallel, but not after the advanced module.
The reading recommendations for primary and specialist literature are determined individually by the respective lecturers according to the subject area and course.

Additional Information
This placeholder can be used for any achievement in the Advanced Unit of the Supplementary Studies.

In the Advanced Module, students can choose their own individual focus, e.g. sustainable development, data literacy, etc. The focus should be discussed with the module coordinator at the FORUM.

3.55 Course: Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Public Debates - Self Registration [T-FORUM-113582]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation: General Studies. Forum Science and Society (FORUM)

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading	Recurrence	Version
Examination of another type	3 CP	graded	Each term	1

Assessment
Another type of examination assessment under § 5, section 3 involves a presentation, term paper, or project work within the chosen course.

Prerequisites
None

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendations
The contents of the basic module are helpful. The basic module should be completed or attended in parallel, but not after the advanced module.
The reading recommendations for primary and specialist literature are determined individually by the respective lecturers according to the subject area and course.

Additional Information
This placeholder can be used for any achievement in the Advanced Unit of the Supplementary Studies.

T 3.56 Course: Elective Specialization Supplementary Studies on Science, Technology and Society / Science in Society - Self-Registration [T-FORUM-113581]

Responsible:	Dr. Christine Mielke Christine Myglas
Organisation:	General Studies. Forum Science and Society (FORUM)
Part of:	M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading	Recurrence	Version
Examination of another type	3 CP	graded	Each term	1

Assessment
Another type of examination assessment under § 5, section 3 involves a presentation, term paper, or project work within the chosen course.

Prerequisites
None

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendations
The contents of the basic module are helpful. The basic module should be completed or attended in parallel, but not after the advanced module.
The reading recommendations for primary and specialist literature are determined individually by the respective lecturers according to the subject area and course.

Additional Information
This placeholder can be used for any achievement in the Advanced Unit of the Supplementary Studies.

T 3.57 Course: Electromagnetics and Numerical Calculation of Fields [T-ETIT-100640]

Responsible: Dr. Yongbo Deng
Prof. Dr. Ulrich Lemmer

Organisation: KIT Department of Electrical Engineering and Information Technology

Part of: M-ETIT-100386 - Electromagnetics and Numerical Calculation of Fields

Type	Credits	Grading	Recurrence	Version
Written examination	4 CP	graded	Each winter term	1

Exams			
ST 2025	7308263	Electromagnetics and Numerical Calculation of Fields	Pauli

Assessment
Success control is carried out in the form of a written test of 120 minutes.

Prerequisites
none

Recommendations
Fundamentals of electromagnetic field theory.

T 3.58 Course: Electronic Properties of Solids I, with Exercises [T-PHYS-102577]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: M-PHYS-102089 - Electronic Properties of Solids I, with Exercises

Type	Credits	Grading	Recurrence	Version
Oral examination	10 CP	graded	Each winter term	1

Events					
WT 25/26	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Wernsdorfer
WT 25/26	4021012	Exercises to Electronic Properties of Solids I	1 SWS	Practice / 🗣	Le Tacon, Wernsdorfer, Cubaynes

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.59 Course: Electronic Properties of Solids I, without Exercises [T-PHYS-102578]

Responsible: Prof. Dr. Matthieu Le Tacon
Prof. Dr. Wolfgang Wernsdorfer
Prof. Dr. Wulf Wulfhekel

Organisation: KIT Department of Physics

Part of: M-PHYS-102090 - Electronic Properties of Solids I, without Exercises

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Each winter term	1

Events					
WT 25/26	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Wernsdorfer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.60 Course: Electronic Properties of Solids II, with Exercises [T-PHYS-104422]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: M-PHYS-102108 - Electronic Properties of Solids II, with Exercises

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Each summer term	1

Events					
ST 2025	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2025	4021112	Exercises to Electronic Properties of Solids II	2 SWS	Practice / 🗣	Ustinov, Fischer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.61 Course: Electronic Properties of Solids II, without Exercises [T-PHYS-104423]

Responsible: Prof. Dr. Matthieu Le Tacon
Dr. Johannes Rotzinger
Prof. Dr. Alexey Ustinov
Prof. Dr. Wolfgang Wernsdorfer

Organisation: KIT Department of Physics

Part of: M-PHYS-102109 - Electronic Properties of Solids II, without Exercises

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Each summer term	1

Events					
ST 2025	4021111	Electronic Properties of Solids II	2 SWS	Lecture / 🗣	Ustinov

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites

none

T 3.62 Course: Ergodic Theory [T-MATH-113086]

Responsible: PD Dr. Gabriele Link
Organisation: KIT Department of Mathematics
Part of: M-MATH-106473 - Ergodic Theory

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	8 CP	graded	Irregular	1 terms	1

Assessment
Oral examination of ca. 20-30 minutes.

Prerequisites
none

Recommendations
Some basic knowledge of measure theory, topology, geometry, group theory and functional analysis is recommended.

Workload
240 hours

T 3.63 Course: Evolution Equations [T-MATH-105844]

Responsible: Prof. Dr. Dorothee Frey
apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: M-MATH-102872 - Evolution Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	0105900	Evolution equations	4 SWS	Lecture	de Rijk
WT 25/26	0105910	Tutorial for 0105900 (Evolution Equations)	2 SWS	Practice	de Rijk

T 3.64 Course: Exponential Integrators [T-MATH-107475]

Responsible: Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke

Organisation: KIT Department of Mathematics

Part of: M-MATH-103700 - Exponential Integrators

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

T 3.65 Course: Extremal Graph Theory [T-MATH-105931]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-102957 - Extremal Graph Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	2

Prerequisites
none

T 3.66 Course: Extreme Value Theory [T-MATH-105908]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-102939 - Extreme Value Theory

Type	Credits	Grading	Version
Oral examination	4 CP	graded	2

T 3.67 Course: Finite Element Methods [T-MATH-105857]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
TT-Prof. Dr. Roland Maier
Prof. Dr. Andreas Rieder
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-102891 - Finite Element Methods

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	0110300	Finite Element Methods	4 SWS	Lecture / 🗣	Hochbruck, Dörich
WT 25/26	0110310	Tutorial for 0110300 (Finite Element Methods)	2 SWS	Practice	Hochbruck, Dörich
Exams					
ST 2025	7700142	Finite Element Methods (examinations on April 23)			Maier

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Below you will find excerpts from events related to this course:

V Finite Element Methods

0110300, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
This course is about numerically solving elliptic boundary value problems using the finite element method. We will introduce necessary basic definitions and then discuss the method in its various aspects. In particular, we will study grid generation, error estimates, and the practical realization of the approach.

Literature
Complete lecture notes will be provided

T 3.68 Course: Forecasting: Theory and Practice [T-MATH-105928]

Responsible: Prof. Dr. Tilmann Gneiting
Organisation: KIT Department of Mathematics
Part of: M-MATH-102956 - Forecasting: Theory and Practice

Type	Credits	Grading	Version
Oral examination	8 CP	graded	2

Events					
ST 2025	0178000	Forecasting: Theory and Practice II	2 SWS	Lecture	Gneiting
ST 2025	0178010	Tutorial for 0178010 (Forecasting: Theory and Practice II)	1 SWS	Practice	Gneiting

Below you will find excerpts from events related to this course:

V Forecasting: Theory and Practice II

0178000, SS 2025, 2 SWS, Language: English, Open in study portal

Lecture (V)

Content
A common desire of all humankind is to make predictions for thefuture. As the future is inherently uncertain, forecasts ought to be probabilistic, i.e., they ought to take the form of probability distributions over future quantities or events. In this class, which is Part I of a two semester series, we will study the probabilistic and statistical foundations of the science of forecasting.

The goal in probabilistic forecasting is to maximize the sharpness of the predictive distributions subject to calibration, based on the information set at hand. Proper scoring rules such as the logarithmic score and the continuous ranked probability score serve to assess calibration and sharpness simultaneously, and relate to information theory and convex analysis. As a special case, consistent scoring functions provide decision-theoretically coherent tools for evaluating point forecasts. Throughout, concepts and methodologies will be illustrated in data examples and case studies.

T 3.69 Course: Formal Systems [T-INFO-101336]

Responsible: Prof. Dr. Bernhard Beckert
Organisation: KIT Department of Informatics
Part of: M-INFO-100799 - Formal Systems

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2424086	Formale Systeme	4 SWS	Lecture / Practice (	Beckert, Ulbrich, Weigl
Exams					
ST 2025	7500009	Formal Systems			Beckert
WT 25/26	7500036	Formal Systems			Beckert

3.70 Course: Foundations of Continuum Mechanics [T-MATH-107044]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: M-MATH-103527 - Foundations of Continuum Mechanics

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Once	2

Events					
ST 2025	0155410	Foundations of continuum mechanics	2 SWS	Lecture	Wieners
ST 2025	0155420	Übungen zu 0155410 (Grundlagen der Kontinuumsmechanik)	1 SWS	Practice	Wieners
Exams					
ST 2025	7700156	Foundations of Continuum Mechanics			Wieners

Assessment
Oral exam of approx. 20 minutes.

Prerequisites
none

T 3.71 Course: Fourier Analysis and its Applications to PDEs [T-MATH-109850]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: M-MATH-104827 - Fourier Analysis and its Applications to PDEs

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	3

Prerequisites
none

T 3.72 Course: Fractal Geometry [T-MATH-111296]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: M-MATH-105649 - Fractal Geometry

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

T 3.73 Course: Functional Analysis [T-MATH-102255]

Responsible: Prof. Dr. Dorothee Frey
PD Dr. Gerd Herzog
Prof. Dr. Dirk Hundertmark
Prof. Dr. Tobias Lamm
TT-Prof. Dr. Xian Liao
Prof. Dr. Wolfgang Reichel
Prof. Dr. Roland Schnaubelt
Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of: M-MATH-101320 - Functional Analysis

Type	Credits	Grading	Recurrence	Version
Written examination	8 CP	graded	Each winter term	3

Events					
WT 25/26	0104800	Functional Analysis	4 SWS	Lecture / 🗣	Hundertmark
WT 25/26	0104810	Tutorial for 0104800 (Functional Analysis)	2 SWS	Practice / 🗣	Hundertmark
Exams					
ST 2025	7700078	Functional Analysis			Frey, Hundertmark, Liao, Reichel, Tolksdorf

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Written examination of 120 minutes.

Prerequisites
none

Workload
240 hours

Below you will find excerpts from events related to this course:

V Functional Analysis
0104800, WS 25/26, 4 SWS, Open in study portal

Lecture (V)
On-Site

Content
The lecture deals with Banach and Hilbert spaces and the linear operators on these spaces. Typical examples are spaces of continuous or integrable functions, and linear operators on these spaces occur in the study of integral and differential equations. The development of functional analysis in the 20th century contributed significantly to the modern theory of differential equations. Today, functional analysis is a fundamental discipline of modern analysis and is widely used, for example, in the theory of partial differential equations, numerical mathematics, mathematical physics and many other areas of application.

Topics of the lecture:
basic properties and examples of metric spaces and Banach spaces, continuous linear operators on Banach spaces, uniform boundedness principle, homomorphism theorem, Hilbert spaces, orthonormal bases, Sobolev spaces, dual spaces, Hahn-Banach theorem, weak convergence, Banach-Alaoglu theorem, reflexivity, compact linear operators

The contents of the basic lectures Analysis 1-3 and Linear Algebra 1+2 are assumed.

Literature

- D. Werner: Funktionalanalysis.

- H.W. Alt: Lineare Funktionalanalysis.
- H. Brezis: Functional Analysis, Sobolev Spaces and Partial Differential Equations.
- J.B. Conway: A Course in Functional Analysis.
- M. Reed, B. Simon: Functional Analysis.
- W. Rudin: Functional Analysis.
- A.E. Taylor, D.C. Lay: Introduction to Functional Analysis.
- J. Wloka: Funktionalanalysis und Anwendungen.

T 3.74 Course: Functional Data Analysis [T-MATH-113102]

Responsible: Dr. rer. nat. Bruno Ebner
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-106485 - Functional Data Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Assessment
Oral examination of ca. 25 minutes.

Prerequisites
none

Recommendations
The contents of the modules "Probability Theory" and "Mathematical Statistics" are strongly recommended.

Workload
120 hours

T 3.75 Course: Functions of Matrices [T-MATH-105906]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: M-MATH-102937 - Functions of Matrices

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Prerequisites
none

T 3.76 Course: Functions of Operators [T-MATH-105905]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102936 - Functions of Operators

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

T 3.77 Course: Generalized Regression Models [T-MATH-105870]

Responsible: Dr. rer. nat. Bruno Ebner
Prof. Dr. Vicky Fasen-Hartmann
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102906 - Generalized Regression Models

Type	Credits	Grading	Version
Oral examination	4 CP	graded	3

Events					
ST 2025	0161400	Generalisierte Regressionsmodelle	2 SWS	Lecture	Ebner
ST 2025	0161410	Übungen zu 0161400 (generalisierte Regressionsmodelle)	1 SWS	Practice	Ebner
Exams					
ST 2025	7700118	Generalized Regression Models			Ebner

Workload
120 hours

T 3.78 Course: Geometric Analysis [T-MATH-105892]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-102923 - Geometric Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Prerequisites
none

Workload
240 hours

T 3.79 Course: Geometric Group Theory [T-MATH-105842]

Responsible: Prof. Dr. Frank Herrlich
PD Dr. Gabriele Link
Jun.-Prof. Dr. Claudio Llosa Isenrich
Prof. Dr. Roman Sauer
Prof. Dr. Wilderich Tuschmann

Organisation: KIT Department of Mathematics

Part of: M-MATH-102867 - Geometric Group Theory

Type	Credits	Grading	Version
Written examination	8 CP	graded	1

Events					
ST 2025	0153300	Geometric Group Theory	4 SWS	Lecture	Link
ST 2025	0153310	Tutorial for 0153300 (Geometric Group Theory)	2 SWS	Practice	Link
Exams					
ST 2025	7700149	Geometric Group Theory			Link

Below you will find excerpts from events related to this course:

V Geometric Group Theory

0153300, SS 2025, 4 SWS, Language: English, Open in study portal

Lecture (V)

Content

This course will provide an introduction to geometric group theory, which studies the interactions between finitely generated groups and geometric spaces, creating connections between algebra and geometry. While a priori groups may seem like purely algebraic objects, they can naturally arise as symmetries of geometric objects. For instance, the symmetries of a regular n-gon form a group (the dihedral group D_n). In fact, every finitely generated group admits a natural action by isometries on a metric space, known as its Cayley graph. For instance the Cayley graph of the integers is the real line with vertices given by the integer points and the group action defined by translation.

Studying group actions on geometric spaces, allows us to gain insights into ``the geometry of groups''. Conversely, knowing that a geometric space admits an interesting group action allows us to obtain a better understanding of the space itself. Over the last decades, these interactions between group theory and geometry have led to an array of fundamental results in both areas. This course will provide an introduction to these interactions and their consequences.

In particular, we will learn about

- finitely generated groups and group presentations
- Cayley graphs and group actions
- quasi-isometries of metric spaces, quasi-isometry invariants and the Theorem of Schwarz-Milnor
- explicit examples of infinite groups and their connections to geometry

Prerequisites are:

Knowledge of the basic concepts on metric and topological spaces, as well as some familiarity with the basic concepts in group theory are recommended.

T 3.80 Course: Geometric Group Theory II [T-MATH-105875]

Responsible: Prof. Dr. Frank Herrlich
Jun.-Prof. Dr. Claudio Llosa Isenrich
Prof. Dr. Roman Sauer

Organisation: KIT Department of Mathematics

Part of: M-MATH-102869 - Geometric Group Theory II

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	0102900	Geometric Group Theory II	4 SWS	Lecture	Fioravanti
WT 25/26	0102910	Tutorial for 0102900 (Geometric Group Theory II)	2 SWS	Practice	Fioravanti

Below you will find excerpts from events related to this course:

V Geometric Group Theory II

0102900, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)

Content

Geometric Group Theory studies algebraic and computational aspects of infinite, finitely generated groups by means of their isometric actions on metric spaces. Arbitrary finitely generated groups can be "arbitrarily wild", and many computational problems are unsolvable in general. For instance, Adyan and Rabin showed in the 1950s that, given a finite presentation of a general finitely presented group, there cannot exist an algorithm telling whether a word in the generators represents the trivial element in the group.

At the same time, most groups naturally arising in geometry and topology are not wild at all. In fact, quite a lot can be said about a group if we know that it admits a "nice" action on a "nice" metric space. Here both occurrences of the word "nice" can be taken to mean quite a lot of different things.

The course will focus on two of the most important classes of "nice" metric spaces, namely CAT(0) spaces and Gromov-hyperbolic spaces. These provide two different ways of formalising the concept of non-positive (or negative) sectional curvature in a purely synthetic way, which avoids any use of differential geometry and applies to "singular" spaces that can fail to be manifolds.

Time permitting, topics covered will include:

- boundaries of hyperbolic groups;
- CAT(0), CAT(+1) and CAT(-1) spaces;
- algebraic and algorithmic properties of hyperbolic and CAT(0) groups;
- Coxeter groups;
- CAT(0) cube complexes.

We will build on the material already covered in the course Geometric Group Theory (SS 2025), including the basics of Gromov-hyperbolic spaces developed there. Familiarity with these concepts is recommended.

Literature

M.Bridson, A.Haefliger, *"Metric spaces of non-positive curvature"*. (Freely available online, among the first results of any search engine.)

T 3.81 Course: Geometric Numerical Integration [T-MATH-105919]

Responsible: Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: M-MATH-102921 - Geometric Numerical Integration

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Prerequisites
none

Workload
180 hours

T 3.82 Course: Geometric Variational Problems [T-MATH-113418]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-106667 - Geometric Variational Problems

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Assessment
oral exam of ca. 30 min

Prerequisites
none

Workload
240 hours

T 3.83 Course: Geometry of Schemes [T-MATH-105841]

Responsible: Prof. Dr. Frank Herrlich
PD Dr. Stefan Kühnlein

Organisation: KIT Department of Mathematics

Part of: M-MATH-102866 - Geometry of Schemes

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.84 Course: Global Differential Geometry [T-MATH-105885]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-102912 - Global Differential Geometry

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Prerequisites
none

Workload
240 hours

3.85 Course: Graph Theory [T-MATH-102273]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-101336 - Graph Theory

Type	Credits	Grading	Version
Written examination	8 CP	graded	2

Events					
WT 25/26	0104500	Graph Theory	4 SWS	Lecture	Aksenovich, Liu
WT 25/26	0104510	Tutorial for 0104500 (Graph Theory)	2 SWS	Practice	Aksenovich, Liu

Prerequisites
None

Below you will find excerpts from events related to this course:

Graph Theory

0104500, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)

Content
Graphs are structures in discrete mathematics that in particular model various networks. The course starts with basic concepts in graph theory such as trees, cycles, matchings, factors, connectivity, and their interconnections. Further topics include properties of graphs with forbidden subgraphs, planar graphs, graph colorings, random graphs, Ramsey theory, and graph minors. Not only classical, but very recent results in the field will be discussed. The class is oriented towards problem solving. Particular attention to proof writing techniques will be paid in the problem class. The final grade will be based on the written exam. Bonus points will be given for weekly or biweekly homework assignments.

T 3.86 Course: Group Actions in Riemannian Geometry [T-MATH-105925]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-102954 - Group Actions in Riemannian Geometry

Type	Credits	Grading	Version
Oral examination	5 CP	graded	1

Prerequisites
none

T 3.87 Course: Harmonic Analysis [T-MATH-111289]

Responsible: Prof. Dr. Dorothee Frey
apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Roland Schnaubelt
Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of: M-MATH-105324 - Harmonic Analysis

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.88 Course: Harmonic Analysis 2 [T-MATH-113103]

Responsible: Prof. Dr. Dorothee Frey
apl. Prof. Dr. Peer Kunstmann
Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of: M-MATH-106486 - Harmonic Analysis 2

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Assessment
oral examination of ca. 30 minutes.

Prerequisites
none

Recommendations
The following modules are strongly recommended: "Harmonic Analysis", "Functional Analysis".

Workload
240 hours

3.89 Course: Heat Transfer II [T-CIWVT-106067]

Responsible: Prof. Dr.-Ing. Thomas Wetzel
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103051 - Heat Transfer II

Type	Credits	Grading	Version
Oral examination	6 CP	graded	3

Events					
WT 25/26	2260020	Heat Transfer II	2 SWS	Lecture / 🗣	Wetzel, Dietrich
WT 25/26	2260021	Exercises on 2260020 Heat Transfer II	1 SWS	Practice / 🗣	Wetzel, Dietrich
Exams					
ST 2025	7260020	Heat Transfer II			Wetzel, Dietrich

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.90 Course: High Temperature Process Engineering [T-CIWVT-106109]

Responsible: Prof. Dr.-Ing. Dieter Stapf
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103075 - High Temperature Process Engineering

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2232210	High Temperature Process Engineering	2 SWS	Lecture / 🗣	Stapf
ST 2025	2232211	High Temperature Process Engineering - Exercises	1 SWS	Practice / 🗣	Stapf, und Mitarbeitende
Exams					
ST 2025	7231001	High Temperature Process Engineering			Stapf
WT 25/26	7231001	High Temperature Process Engineering			Stapf

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
None

T 3.91 Course: Homotopy Theory [T-MATH-105933]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: M-MATH-102959 - Homotopy Theory

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.92 Course: Infinite dimensional dynamical systems [T-MATH-107070]

Responsible: Prof. Dr. Jens Rottmann-Matthes
Organisation: KIT Department of Mathematics
Part of: M-MATH-103544 - Infinite dimensional dynamical systems

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites
none

T 3.93 Course: Information Security [T-INFO-112195]

Responsible: Prof. Dr. Hannes Hartenstein
Prof. Dr. Thorsten Strufe
Organisation: KIT Department of Informatics
Part of: M-INFO-106015 - Information Security

Type	Credits	Grading	Recurrence	Version
Written examination	5 CP	graded	Each summer term	2

Events					
ST 2025	2400199	Informationssicherheit	3 SWS	Lecture / Practice (/ 🗣	Müller-Quade, Strufe, Hartenstein, Wressnegger
Exams					
ST 2025	7500028	Information Security			Müller-Quade, Wressnegger, Strufe, Hartenstein
ST 2025	7500368	Information Security			Strufe, Hartenstein

Legend: 🖥 Online, ❁ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-101371 - Security must not have been started.

T 3.94 Course: Integral Equations [T-MATH-105834]

Responsible: PD Dr. Tilo Arens
Prof. Dr. Roland Griesmaier
PD Dr. Frank Hettlich

Organisation: KIT Department of Mathematics

Part of: M-MATH-102874 - Integral Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

T 3.95 Course: Integrated Photonics [T-ETIT-114418]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-107344 - Integrated Photonics

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Assessment
The assessment takes place in the form of an oral examination (approx. 25 minutes); appointments individually on demand.

Prerequisites
none

T 3.96 Course: Internet Seminar for Evolution Equations [T-MATH-105890]

Responsible: Prof. Dr. Dorothee Frey
apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Roland Schnaubelt
Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of: M-MATH-102918 - Internet Seminar for Evolution Equations

Type	Credits	Grading	Version
Written examination	8 CP	graded	1

Events					
WT 25/26	0105000	Internetseminar für Evolutionsgleichungen	2 SWS	Lecture / 🗣	Schnaubelt, Kunstmann, Frey, Tolksdorf

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
oral examination of ca. 30 minutes

Prerequisites
none

Workload
240 hours

T 3.97 Course: Internship [T-MATH-105888]

Responsible: Prof. Dr. Willy Dörfler
PD Dr. Markus Neher

Organisation: KIT Department of Mathematics

Part of: M-MATH-102861 - Internship

Type	Credits	Grading	Version
Coursework	10 CP	pass/fail	1

T 3.98 Course: Interpolation Spaces [T-MATH-114639]

Responsible: apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Tobias Lamm

Organisation: KIT Department of Mathematics

Part of: M-MATH-107456 - Interpolation Spaces

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Assessment
Oral examination lasting approx. 30 minutes.

Prerequisites
none

Workload
180 hours

T 3.99 Course: Introduction into Particulate Flows [T-MATH-105911]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: M-MATH-102943 - Introduction into Particulate Flows

Type	Credits	Grading	Version
Oral examination	3 CP	graded	1

Prerequisites
none

T 3.100 Course: Introduction to Artificial Intelligence [T-INFO-112194]

Responsible: TT-Prof. Dr. Pascal Friederich
Prof. Dr. Gerhard Neumann

Organisation: KIT Department of Informatics

Part of: M-INFO-106014 - Introduction to Artificial Intelligence

Type	Credits	Grading	Recurrence	Version
Written examination	5 CP	graded	Each winter term	6

Events					
WT 25/26	2400158	Introduction to Artificial Intelligence	3 SWS	Lecture / Practice (/ 🗣	Schäfer, Nowack, Friederich, Neumann
Exams					
ST 2025	7500058	Introduction to Artificial Intelligence			Neumann, Friederich, Schäfer
WT 25/26	7500136	Introduction to Artificial Intelligence			Nowack, Friederich, Schäfer, Neumann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-101356 - Cognitive Systems must not have been started.

T 3.101 Course: Introduction to Convex Integration [T-MATH-112119]

Responsible: Dr. Christian Zillinger
Organisation: KIT Department of Mathematics
Part of: M-MATH-105964 - Introduction to Convex Integration

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	3 CP	graded	Irregular	1 terms	1

Assessment
oral examination of approx. 30 minutes

Prerequisites
none

Recommendations
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

Workload
90 hours

T 3.102 Course: Introduction to Cosmology [T-PHYS-102384]

Responsible: Prof. Dr. Guido Drexlin
Organisation: KIT Department of Physics
Part of: M-PHYS-102175 - Introduction to Cosmology

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	4022021	Introduction to Cosmology	2 SWS	Lecture / 🗣	Valerius, Lokhov
WT 25/26	4022022	Exercises to Introduction to Cosmology	1 SWS	Practice / 🗣	Valerius, NN

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Introduction to Cosmology

4022021, WS 25/26, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
An Introduction to cosmology from the Big Bang to the present universe

T 3.103 Course: Introduction to Dynamical Systems [T-MATH-113263]

Responsible: Dr. Björn de Rijk
Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-106591 - Introduction to Dynamical Systems

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Assessment
oral exam of ca. 30 min

Prerequisites
none

Workload
180 hours

T 3.104 Course: Introduction to Fluid Dynamics [T-MATH-111297]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-105650 - Introduction to Fluid Dynamics

Type	Credits	Grading	Recurrence	Version
Oral examination	3 CP	graded	Irregular	1

Prerequisites
none

T 3.105 Course: Introduction to Fluid Mechanics [T-MATH-112927]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: M-MATH-106401 - Introduction to Fluid Mechanics

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	6 CP	graded	Irregular	1 terms	1

Assessment
The module examination takes the form of an oral examination of approx. 25 minutes.

Prerequisites
none

Recommendations
The module *Functional Analysis* is strongly recommended.

Workload
180 hours

T 3.106 Course: Introduction to Geometric Measure Theory [T-MATH-105918]

Responsible: PD Dr. Steffen Winter
Organisation: KIT Department of Mathematics
Part of: M-MATH-102949 - Introduction to Geometric Measure Theory

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Prerequisites
none

T 3.107 Course: Introduction to Homogeneous Dynamics [T-MATH-110323]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: M-MATH-105101 - Introduction to Homogeneous Dynamics

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

T 3.108 Course: Introduction to Kinetic Equations [T-MATH-111721]

Responsible: Dr. Christian Zillinger
Organisation: KIT Department of Mathematics
Part of: M-MATH-105837 - Introduction to Kinetic Equations

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	3 CP	graded	Irregular	1 terms	1

Assessment
oral examination of circa 30 minutes

Prerequisites
none

Recommendations
The course "Classical Methods for Partial Differential Equations" should be studied beforehand.

T 3.109 Course: Introduction to Kinetic Theory [T-MATH-108013]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: M-MATH-103919 - Introduction to Kinetic Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Each winter term	1

Events					
WT 25/26	0155450	Introduction to Kinetic Theory	2 SWS	Lecture	Loevbak
WT 25/26	0155460	Tutorial for 0155450 (Introduction to Kinetic Theory)	1 SWS	Practice	Loevbak
Exams					
ST 2025	7700158	Introduction to Kinetic Theory			Frank

Prerequisites
none

Below you will find excerpts from events related to this course:

V Introduction to Kinetic Theory

0155450, WS 25/26, 2 SWS, Language: English, Open in study portal

Lecture (V)

Content
Kinetic descriptions play an important role in a variety of physical, biological, and even social applications, for instance, in the description of gases, radiations, bacteria or financial markets. Typically, these systems are described locally not by a finite set of variables but instead by a probability density describing the distribution of a microscopic state. Its evolution is typically given by an integro-differential equation. Unfortunately, the large phase space associated with the kinetic description has made simulations impractical in most settings in the past. However, recent advances in computer resources, reduced-order modeling and numerical algorithms are making accurate approximations of kinetic models more tractable, and this trend is expected to continue in the future. On the theoretical mathematical side, two rather recent Fields medals (Pierre-Louis Lions 1994, Cédric Villani 2010) also indicate the continuing interest in this field, which was already the subject of Hilbert's sixth out of the 23 problems presented at the World Congress of Mathematicians in 1900.

This course gives an introduction to kinetic theory. Our purpose is to discuss the mathematical passage from a microscopic description of a system of particles, via a probabilistic description to a macroscopic view. This is done in a complete way for the linear case of particles that are interacting with a background medium. The nonlinear case of pairwise interacting particles is treated on a more phenomenological level.

An extremely broad range of mathematical techniques is used in this course. Besides mathematical modeling, we make use of statistics and probability theory, ordinary differential equations, hyperbolic partial differential equations, integral equations (and thus functional analysis) and infinite-dimensional optimization. Among the astonishing discoveries of kinetic theory are the statistical interpretation of the Second Law of Thermodynamics, induced by the Boltzmann-Grad limit, and the result that the macroscopic equations describing fluid motion (namely the Euler and Navier-Stokes equations) can be inferred from abstract geometrical properties of integral scattering operators.

T 3.110 Course: Introduction to Microlocal Analysis [T-MATH-111722]

Responsible: TT-Prof. Dr. Xian Liao
Organisation: KIT Department of Mathematics
Part of: M-MATH-105838 - Introduction to Microlocal Analysis

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	3 CP	graded	Irregular	1 terms	1

Assessment
oral examination of circa 30 minutes

Prerequisites
none

Recommendations
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" should be studied beforehand.

T 3.111 Course: Introduction to Python [T-MATH-106119]

Responsible: Dr. Daniel Weiß
Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Recurrence	Version
Examination of another type	4 CP	pass/fail	Each summer term	2

Events					
ST 2025	0169000	Einführung in Python	1 SWS	Lecture	Weiß
Exams					
ST 2025	7700018	Introduction to Python			Weiß

Workload
120 hours

T 3.112 Course: Introduction to Scientific Computing [T-MATH-105837]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Prof. Dr. Andreas Rieder
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-102889 - Introduction to Scientific Computing

Type	Credits	Grading	Version
Oral examination	8 CP	graded	3

Events					
ST 2025	0165000	Einführung in das Wissenschaftliche Rechnen	3 SWS	Lecture	Hochbruck, Dörich
ST 2025	0165010	Praktikum zu 0165000 (Einführung in das Wissenschaftliche Rechnen)	3 SWS	Practical course	Hochbruck, Dörich
Exams					
ST 2025	7700147	Introduction to Scientific Computing			Hochbruck, Dörich
ST 2025	7700148	Introduction to Scientific Computing			Dörich, Hochbruck

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-MATH-114059 - Project Lab Scientific Computing must have been passed.

T 3.113 Course: Introduction to Stochastic Differential Equations [T-MATH-112234]

Responsible: Josef Janák
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-106045 - Introduction to Stochastic Differential Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Assessment
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Recommendations
The contents of the module "Probability Theory" are strongly recommended. The module "Continuous Time Finance" is recommended.

Workload
120 hours

T 3.114 Course: Inverse Problems [T-MATH-105835]

Responsible: PD Dr. Tilo Arens
Prof. Dr. Roland Griesmaier
PD Dr. Frank Hettlich
Prof. Dr. Andreas Rieder

Organisation: KIT Department of Mathematics

Part of: M-MATH-102890 - Inverse Problems

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	0105100	Inverse Problems	4 SWS	Lecture / 🗣	Griesmaier
WT 25/26	0105110	Tutorial for 0105100 (Inverse Problems)	2 SWS	Practice / 🗣	Griesmaier
Exams					
ST 2025	7700120	Inverse Problems			Rieder

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Inverse Problems

0105100, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content

Following Hadamard, a problem whose solution does not depend continuously on the given data is called ill-posed. Prominent examples are the mathematical problems behind tomographic methods like X-ray tomography, ultrasound tomography or electrical impedance tomography as well as seismic imaging, radar imaging, or inverse scattering. The mathematical models used in this context are typically formulated in terms of integral transforms or differential equations. However the aim is not to evaluate the transform or to solve the differential equation but to invert the transform or to reconstruct parameters of this equation given (part of) its solution, respectively. Therefore these problems are called inverse problems.

Standard methods from numerical mathematics typically fail when they are directly applied to ill-posed problems -- the problem has to be regularized. The course gives an introduction to the functional analytic background of regularization methods for linear ill-posed problems. Results from functional analysis that are required in this context will be provided in the course of the lecture.

T 3.115 Course: IT Security [T-INFO-113960]

Responsible: Prof. Dr. Jörn Müller-Quade
Prof. Dr. Christian Wressnegger

Organisation: KIT Department of Informatics

Part of: M-INFO-106998 - IT Security

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	2

Events					
WT 25/26	2400010	IT Security	4 SWS	Lecture / Practice (/ 🗣	Müller-Quade, Wressnegger, Martin, Tiepelt
Exams					
ST 2025	7500025	IT Security (Nachklausur)			Müller-Quade, Wressnegger, Strufe
ST 2025	7500381	IT Security			Müller-Quade, Wressnegger, Strufe

Legend: 🖥 Online, ❖ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 90 minutes.

Prerequisites
None.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-112818 - IT Security must not have been started.
2. The course T-INFO-101371 - Security must not have been started.

Recommendations
Students should be familiar with the content of the compulsory lecture "Informationssicherheit".

T 3.116 Course: Lecture Series Supplementary Studies on Science, Technology and Society - Self Registration [T-FORUM-113578]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation: General Studies. Forum Science and Society (FORUM)

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading	Recurrence	Expansion	Version
Coursework	2 CP	pass/fail	Each summer term	1 terms	1

Assessment
Active participation, learning protocols, if applicable.

Prerequisites
None

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)
- FORUM (ehem. ZAK) Begleitstudium

Recommendations
It is recommended that you complete the lecture series "Science in Society" before attending events in the advanced module and in parallel with attending the basic seminar.
If it is not possible to attend the lecture series and the basic seminar in the same semester, the lecture series can also be attended after attending the basic seminar.
However, attending events in the advanced module before attending the lecture series should be avoided.

Additional Information
The basic module consists of the lecture series "Science in Society" and the basic seminar. The lecture series is only offered during the summer semester.
The basic seminar can be attended in the summer or winter semester.

T 3.117 Course: Lie Groups and Lie Algebras [T-MATH-108799]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: **M-MATH-104261 - Lie Groups and Lie Algebras**

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.118 Course: Lie-Algebras [T-MATH-113907]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: M-MATH-106950 - Lie-Algebras

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	8 CP	graded	Irregular	1 terms	1

Prerequisites
none

T 3.119 Course: Localization of Mobile Agents [T-INFO-101377]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100840 - Localization of Mobile Agents

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each summer term	2

Events					
ST 2025	24613	Localization of Mobile Agents	3 SWS	Lecture / 🗣	Hanebeck, Frisch
Exams					
ST 2025	7500482	Localization of Mobile Agents			Hanebeck

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment takes the form of an oral examination, usually lasting 15 minutes in accordance with Section 4 (2) No. 2 of the SPO.

It will be announced six weeks before the examination (§ 6 Para. 3 SPO) whether the performance assessment

- in the form of an oral examination in accordance with § 4 Para. 2 No. 2 SPO **or**
- in the form of a written examination in accordance with § 4 Para. 2 No. 1 SPO

will take place.

Prerequisites
None.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-114169 - Localization of Mobile Agents Pass must have been started.

Recommendations
Basic knowledge of linear algebra and stochastics is helpful.

Below you will find excerpts from events related to this course:

V Localization of Mobile Agents
24613, SS 2025, 3 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Content
This module provides a systematic introduction into the topic of localization methods. In order to facilitate understanding, the module is divided into four main topics. Dead reckoning treats the instantaneous determination of a vehicle's position based on dynamic parameters like velocity or steering angle. Localization with the help of measurements of known landmarks is part of static localization. In addition to the closed-form solutions for particular measurements (distances and angles), the least squares method for fusion arbitrary measurements is also introduced. Dynamic localization treats the combination of dead reckoning and static localization. The central part of the lecture is the derivation of the Kalman filter, which has been successfully applied in several practical applications. Finally, simultaneous localization and mapping (SLAM) is introduced, which allows localization in case of (partly) unknown landmark positions.

Organizational issues
Präsenz-Vorlesung und digitale/online Übung mit ILIAS Tests.

Terminvereinbarung für mündliche Prüfung unter: pruefung-isas@iar.kit.edu

Literature
Grundlegende Kenntnisse der linearen Algebra und Stochastik sind hilfreich.

T 3.120 Course: Localization of Mobile Agents Pass [T-INFO-114169]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100840 - Localization of Mobile Agents

Type	Credits	Grading	Recurrence	Version
Coursework	0 CP	pass/fail	Each summer term	1

Exams			
ST 2025	7500483	Localization of Mobile Agents - Pass	Hanebeck

Assessment
The assessment is carried out in form of course work (German Studienleistung, § 4 Abs. 3 SPO).

The assessment is carried out in digital form. There are ILIAS tests with individual, randomized tasks that can be solved by hand or with a small numerical program. User input is automatically assessed and there is instant feedback. There is no limit on retakes. All tests must be passed; learning progress is displayed in ILIAS.

Prerequisites
None.

Recommendations
Basic knowledge of linear algebra and stochastics is helpful.

T 3.121 Course: Logical Foundations of Cyber-Physical Systems [T-INFO-112360]

Responsible: Prof. Dr. André Platzer
Organisation: KIT Department of Informatics
Part of: M-INFO-106102 - Logical Foundations of Cyber-Physical Systems

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	3

Events					
WT 25/26	2400161	Logical Foundations of Cyber-Physical Systems	4 SWS	Lecture / 🗣	Platzer

Legend: 🖥 Online, ✣ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is usually carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 120 minutes.

Depending on the number of participants, it will be announced six weeks before the examination (Section 6 (3) SPO) whether the assessment will take the form of an oral examination of approx.
- in the form of an oral examination of approx. 30 minutes in accordance with § 4 Para. 2 No. 2 SPO or
- in the form of a written examination in accordance with § 4 Para. 2 No. 1 SPO
takes place.

In order to receive a bonus, you must earn at least 50% of the points for solving the exercises. If the grade of the written examination is between 4.0 and 1.3, the bonus improves the grade by one grade level (0.3 or 0.4).

Prerequisites
None.

Recommendations
The course assumes prior exposure to basic computer programming and mathematical reasoning. This course covers the basic required mathematical and logical background of cyber-physical systems. You will be expected to follow the textbook as needed: André Platzer. Logical Foundations of Cyber-Physical Systems. Springer 2018. DOI:10.1007/978-3-319-63588-0

Additional Information
Course web page: https://lfcps.org/course/lfcps.html

T 3.122 Course: Markov Decision Processes [T-MATH-105921]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: M-MATH-102907 - Markov Decision Processes

Type	Credits	Grading	Version
Oral examination	5 CP	graded	1

Events					
ST 2025	0159900	Markov Decision Processes	2 SWS	Lecture	Bäuerle
ST 2025	0159910	Tutorial for 0159900 (Markov Decision Processes)	2 SWS	Practice	Bäuerle
Exams					
ST 2025	77341	Markov Decision Processes			Bäuerle

Prerequisites
none

Workload
150 hours

Below you will find excerpts from events related to this course:

V Markov Decision Processes

Lecture (V)

0159900, SS 2025, 2 SWS, Open in study portal

Content
Problems often arise in applications where it is necessary to intervene in a stochastic, dynamic system in order to control it optimally. Examples are portfolio optimization problems: how do I allocate and reallocate my money across different investments to maximize my expected benefit? Scheduling problems: in which order should I process waiting jobs to maximize production flow? Or stopping problems: when should I sell a stock or when should I stop on games like 17 and 4? The lecture offers an introduction to the optimal control of discrete-time Markovian processes and their solution theory. Important application examples are also covered.

3.123 Course: Master's Thesis [T-MATH-105878]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: M-MATH-102917 - Master's Thesis

Type	Credits	Grading	Version
Final Thesis	30 CP	graded	1

Final Thesis
This course represents a final thesis. The following periods have been supplied:

Submission deadline	6 months
Maximum extension period	3 months
Correction period	8 weeks

T 3.124 Course: Mathematical Methods in Signal and Image Processing [T-MATH-105862]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102897 - Mathematical Methods in Signal and Image Processing

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Prerequisites
none

Workload
240 hours

T 3.125 Course: Mathematical Methods of Imaging [T-MATH-106488]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-103260 - Mathematical Methods of Imaging

Type	Credits	Grading	Recurrence	Version
Oral examination	5 CP	graded	Irregular	1

Events					
WT 25/26	0100052	Mathematische Methoden der Bildgebung	2 SWS	Lecture	Rieder
WT 25/26	0100061	Übungen zu 0102900 (mathematische Methoden der Bildgebung)	2 SWS	Practice	Rieder

Prerequisites
None

T 3.126 Course: Mathematical Modelling and Simulation in Practise [T-MATH-105889]

Responsible: PD Dr. Gudrun Thäter
Organisation: KIT Department of Mathematics
Part of: M-MATH-102929 - Mathematical Modelling and Simulation in Practise

Type	Credits	Grading	Version
Oral examination	4 CP	graded	2

Events					
WT 25/26	0109400	Mathematical Modelling and Simulation	2 SWS	Lecture / 🗣	Thäter
WT 25/26	0109410	Tutorial for 0109400 (Mathematical modelling and simulation)	1 SWS	Practice	Thäter

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Mathematical Modelling and Simulation

0109400, WS 25/26, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
The general aim of this lecture course is threefold:

1) to interconnect different mathematical fields
2) to connect mathematics and real life problems
3) to learn to be critical and to ask relevant questions

We deal with topics such as

- Game theory
- Oscillation
- Population Models
- Simulation of traffic
- Chaotic behavior
- Heat conduction
- Fluids and Flow

There are no special prerequisites.

During the lecture course there will be one lecture of a person from industry (around the Christmas break) and one excursion (at the end of the lecture course).

To earn the credits you have to attend the lecture and finish the work on one project during the term in a group of 2-3 persons. The topic of the project is up to the choice of each group.

The exam is an oral exam.

Literature:
Hans-Joachim Bungartz e.a.: Modeling and Simulation: An Application-Oriented Introduction,
Springer, 2013 (English)

T 3.127 Course: Mathematical Statistics [T-MATH-105872]

Responsible: Dr. rer. nat. Bruno Ebner
Prof. Dr. Vicky Fasen-Hartmann
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102909 - Mathematical Statistics

Type	Credits	Grading	Version
Oral examination	8 CP	graded	2

Exams			
ST 2025	7700136	Mathematical Statistics (Termin 2)	Klar

Prerequisites
none

Workload
240 hours

T 3.128 Course: Mathematical Topics in Kinetic Theory [T-MATH-108403]

Responsible: Prof. Dr. Dirk Hundertmark
Organisation: KIT Department of Mathematics
Part of: M-MATH-104059 - Mathematical Topics in Kinetic Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites
none

T 3.129 Course: Maxwell's Equations [T-MATH-105856]

Responsible: PD Dr. Tilo Arens
Prof. Dr. Roland Griesmaier
PD Dr. Frank Hettlich

Organisation: KIT Department of Mathematics

Part of: M-MATH-102885 - Maxwell's Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.130 Course: Medical Imaging Technology [T-ETIT-113625]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106778 - Medical Imaging Technology

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2305263	Medical Imaging Technology	4 SWS	Lecture / Practice (/ 🗣	Spadea, Arndt
Exams					
ST 2025	7305260	Medical Imaging Technology			Spadea, Arndt
WT 25/26	7305260	Medical Imaging Technology			Spadea

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination takes place in form of a written examination lasting 120 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 3.131 Course: Metric Geometry [T-MATH-111933]

Responsible: Prof. Dr. Alexander Lytchak
Dr. Artem Nepechiy

Organisation: KIT Department of Mathematics

Part of: M-MATH-105931 - Metric Geometry

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Assessment
oral examination of circa 20 minutes

Prerequisites
none

T 3.132 Course: Minimal Surfaces [T-MATH-113417]

Responsible: Dr. Peter Lewintan
Organisation: KIT Department of Mathematics
Part of: M-MATH-106666 - Minimal Surfaces

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	3 CP	graded	Irregular	1 terms	1

Prerequisites
None

Workload
90 hours

T 3.133 Course: Modelling and Simulation of Lithium-Ion Batteries [T-MATH-113382]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: M-MATH-106640 - Modelling and Simulation of Lithium-Ion Batteries

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Assessment
oral exam (ca. 20 min)

Prerequisites
None

Workload
120 hours

T 3.134 Course: Models of Mathematical Physics [T-MATH-105846]

Responsible:	Prof. Dr. Dirk Hundertmark Prof. Dr. Michael Plum Prof. Dr. Wolfgang Reichel
Organisation:	KIT Department of Mathematics
Part of:	**M-MATH-102875 - Models of Mathematical Physics**

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.135 Course: Modern Experimental Physics I, Atoms, Nuclei and Molecules [T-PHYS-112846]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-106331 - Modern Experimental Physics I, Atoms, Nuclei and Molecules

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Each summer term	1

Events					
ST 2025	4010041	Modern Experimental Physics I, Atoms, Nuclei and Molecules	4 SWS	Lecture / 🗣	Valerius, Lokhov
ST 2025	4010042	Übungen zu Moderne Experimentalphysik I	2 SWS	Practice / 🗣	Valerius, Lokhov

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Oral exam, approx. 45 min

Prerequisites
successful completion of the exercises

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The following conditions have to be fulfilled:

T 3.136 Course: Modern Experimental Physics II, Structure of Matter [T-PHYS-112847]

Responsible: Studiendekan Physik
Organisation: KIT Department of Physics
Part of: M-PHYS-106332 - Modern Experimental Physics II, Structure of Matter

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Each winter term	1

Events					
WT 25/26	4010051	Moderne Experimentalphysik II (Struktur der Materie)	4 SWS	Lecture / 🗣	Wegener, Rabbertz
WT 25/26	4010052	Übungen zu Moderne Experimentalphysik II	2 SWS	Practice / 🗣	Wegener, Rabbertz, Fischer, NN

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Oral exam, approx. 45 min

Prerequisites
successful completion of the exercises

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The following conditions have to be fulfilled:

T 3.137 Course: Modern Methods in Combinatorics [T-MATH-113911]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-106957 - Modern Methods in Combinatorics

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Exams			
ST 2025	7700157	Modern Methods in Combinatorics	Sagdeev

Assessment
Oral examination (approx. 30 min)

Prerequisites
None

Workload
180 hours

T 3.138 Course: Modular Forms [T-MATH-105843]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: M-MATH-102868 - Modular Forms

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.139 Course: Monotonicity Methods in Analysis [T-MATH-105877]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: M-MATH-102887 - Monotonicity Methods in Analysis

Type	Credits	Grading	Version
Oral examination	3 CP	graded	1

T 3.140 Course: Multigrid and Domain Decomposition Methods [T-MATH-105863]

Responsible: Prof. Dr. Christian Wieners
Organisation: KIT Department of Mathematics
Part of: M-MATH-102898 - Multigrid and Domain Decomposition Methods

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Assessment
Mündliche Prüfung im Umfang von ca. 20 Minuten.

Prerequisites
none

Workload
120 hours

T 3.141 Course: Neural Networks [T-INFO-101383]

Responsible: Prof. Dr. Alexander Waibel
Organisation: KIT Department of Informatics
Part of: M-INFO-100846 - Neural Networks

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2400024	Deep Learning and Neural Networks	4 SWS	Lecture / 🗣	Niehues
Exams					
ST 2025	7500044	Deep Learning and Neural Networks			Niehues, Waibel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-109124 - Deep Learning and Neural Networks must not have been started.

T 3.142 Course: Nonlinear Analysis [T-MATH-107065]

Responsible: Prof. Dr. Tobias Lamm
Organisation: KIT Department of Mathematics
Part of: M-MATH-103539 - Nonlinear Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Prerequisites
none

T 3.143 Course: Nonlinear Control Systems [T-ETIT-100980]

Responsible: Dr.-Ing. Mathias Kluwe
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100371 - Nonlinear Control Systems

Type	Credits	Grading	Recurrence	Version
Written examination	3 CP	graded	Each summer term	1

Events					
ST 2025	2303173	Nichtlineare Regelungssysteme	2 SWS	Lecture / 🗣	Kluwe
Exams					
ST 2025	7303173	Nonlinear Control Systems			Kluwe

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.144 Course: Nonlinear Evolution Equations [T-MATH-105848]

Responsible: Prof. Dr. Dorothee Frey
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: M-MATH-102877 - Nonlinear Evolution Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.145 Course: Nonlinear Functional Analysis [T-MATH-105876]

Responsible: PD Dr. Gerd Herzog
Organisation: KIT Department of Mathematics
Part of: M-MATH-102886 - Nonlinear Functional Analysis

Type	Credits	Grading	Version
Oral examination	3 CP	graded	1

T 3.146 Course: Nonlinear Maxwell Equations [T-MATH-110283]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: M-MATH-105066 - Nonlinear Maxwell Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Exams			
ST 2025	7700115	Nonlinear Maxwell Equations	Schnaubelt

Prerequisites
none

T 3.147 Course: Nonlinear Wave Equations [T-MATH-110806]

Responsible: Prof. Dr. Wolfgang Reichel
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: M-MATH-105326 - Nonlinear Wave Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites

none

T 3.148 Course: Nonparametric Statistics [T-MATH-105873]

Responsible: Dr. rer. nat. Bruno Ebner
Prof. Dr. Vicky Fasen-Hartmann
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102910 - Nonparametric Statistics

Type	Credits	Grading	Version
Oral examination	4 CP	graded	2

Assessment
oral exam of ca. 20 minutes

Workload
120 hours

T 3.149 Course: Numerical Analysis of Helmholtz Problems [T-MATH-111514]

Responsible: TT-Prof. Dr. Barbara Verfürth
Organisation: KIT Department of Mathematics
Part of: M-MATH-105764 - Numerical Analysis of Helmholtz Problems

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	3 CP	graded	Irregular	1 terms	1

T 3.150 Course: Numerical Analysis of Neural Networks [T-MATH-113470]

Responsible: TT-Prof. Dr. Roland Maier
Organisation: KIT Department of Mathematics
Part of: M-MATH-106695 - Numerical Analysis of Neural Networks

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Workload
180 hours

T 3.151 Course: Numerical Complex Analysis [T-MATH-112280]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: M-MATH-106063 - Numerical Complex Analysis

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	6 CP	graded	Irregular	1 terms	1

Assessment
oral exam of ca. 20 minutes

Prerequisites
none

Recommendations
Some basic knowledge of Complex Analysis is strongly recommended.

Workload
180 hours

T 3.152 Course: Numerical Linear Algebra for Scientific High Performance Computing [T-MATH-107497]

Responsible: Prof. Dr. Hartwig Anzt
Organisation: KIT Department of Mathematics
Part of: M-MATH-103709 - Numerical Linear Algebra for Scientific High Performance Computing

Type	Credits	Grading	Recurrence	Version
Examination of another type	5 CP	graded	Irregular	2

Prerequisites
none

T 3.153 Course: Numerical Linear Algebra in Image Processing [T-MATH-108402]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: M-MATH-104058 - Numerical Linear Algebra in Image Processing

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

T 3.154 Course: Numerical Methods for Differential Equations [T-MATH-105836]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Prof. Dr. Andreas Rieder
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-102888 - Numerical Methods for Differential Equations

Type	Credits	Grading	Recurrence	Version
Written examination	8 CP	graded	Each winter term	3

Events					
WT 25/26	0110700	Numerische Methoden für Differentialgleichungen	4 SWS	Lecture / 🗣	Jahnke
WT 25/26	0110800	Übungen zu 0110700 (numerische Methoden für Differentialgleichungen)	2 SWS	Practice / 🗣	Jahnke
Exams					
ST 2025	7700007	Numerical Methods for Differential Equations			Hochbruck

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Success is assessed in form of an oral or written examination. This will be determined by the lecturer at the beginning of the course.

Prerequisites
None

Workload
240 hours

T 3.155 Course: Numerical Methods for Hyperbolic Equations [T-MATH-105900]

Responsible: Prof. Dr. Willy Dörfler
Organisation: KIT Department of Mathematics
Part of: M-MATH-102915 - Numerical Methods for Hyperbolic Equations

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Prerequisites
none

Workload
180 hours

T 3.156 Course: Numerical Methods for Integral Equations [T-MATH-105901]

Responsible: PD Dr. Tilo Arens
PD Dr. Frank Hettlich

Organisation: KIT Department of Mathematics

Part of: M-MATH-102930 - Numerical Methods for Integral Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Exams			
ST 2025	7700114	Numerical Methods for Integral Equations	Arens

T 3.157 Course: Numerical Methods for Maxwell's Equations [T-MATH-105920]

Responsible: Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke

Organisation: KIT Department of Mathematics

Part of: M-MATH-102931 - Numerical Methods for Maxwell's Equations

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

T 3.158 Course: Numerical Methods for Oscillatory Differential Equations [T-MATH-113437]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: M-MATH-106682 - Numerical Methods for Oscillatory Differential Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Workload
240 hours

T 3.159 Course: Numerical Methods for Time-Dependent Partial Differential Equations [T-MATH-105899]

Responsible: Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: M-MATH-102928 - Numerical Methods for Time-Dependent Partial Differential Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Assessment
Success is assessed in form of an oral examination lasting approx. 25 minutes.

Prerequisites
None.

Workload
240 hours

T 3.160 Course: Numerical Methods in Computational Electrodynamics [T-MATH-105860]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Prof. Dr. Andreas Rieder
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-102894 - Numerical Methods in Computational Electrodynamics

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Prerequisites
none

Workload
180 hours

T 3.161 Course: Numerical Methods in Fluid Mechanics [T-MATH-105902]

Responsible: Prof. Dr. Willy Dörfler
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: M-MATH-102932 - Numerical Methods in Fluid Mechanics

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

T 3.162 Course: Numerical Methods in Mathematical Finance [T-MATH-105865]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: M-MATH-102901 - Numerical Methods in Mathematical Finance

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Exams			
ST 2025	7700055	Numerical Methods in Mathematical Finance	Jahnke

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Workload
240 hours

T 3.163 Course: Numerical Optimisation Methods [T-MATH-105858]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Prof. Dr. Andreas Rieder
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-102892 - Numerical Optimisation Methods

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	0124000	Numerische Optimierungsmethoden	4 SWS	Lecture	Wieners
WT 25/26	0124010	Übungen zu 0124000 (numerische Optimierungsmethoden)	2 SWS	Practice	Wieners

T 3.164 Course: Numerical Simulation in Molecular Dynamics [T-MATH-110807]

Responsible: PD Dr. Volker Grimm
Organisation: KIT Department of Mathematics
Part of: M-MATH-105327 - Numerical Simulation in Molecular Dynamics

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Prerequisites
none

3.165 Course: Optimal Control and Estimation [T-ETIT-104594]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-102310 - Optimal Control and Estimation

Type	Credits	Grading	Recurrence	Version
Oral examination	3 CP	graded	Each summer term	1

Events					
ST 2025	2303162	Optimal Control and Estimation	2 SWS	Lecture / 🗣	Kluwe
Exams					
ST 2025	7303162	Optimal Control and Estimation			Kluwe

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

3.166 Course: Optimisation and Optimal Control for Differential Equations [T-MATH-105864]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102899 - Optimisation and Optimal Control for Differential Equations

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Prerequisites
none

Workload
120 hours

T 3.167 Course: Optimization in Banach Spaces [T-MATH-105893]

Responsible: Prof. Dr. Roland Griesmaier
PD Dr. Frank Hettlich

Organisation: KIT Department of Mathematics

Part of: M-MATH-102924 - Optimization in Banach Spaces

Type	Credits	Grading	Version
Oral examination	5 CP	graded	2

Assessment
oral examination of approximately 30 minutes

Prerequisites
none

Recommendations
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.

Workload
150 hours

T 3.168 Course: Optimization of Dynamic Systems [T-ETIT-100685]

Responsible: Prof. Dr.-Ing. Sören Hohmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100531 - Optimization of Dynamic Systems

Type	Credits	Grading	Recurrence	Version
Written examination	5 CP	graded	Each winter term	1

Events					
WT 25/26	2303183	Optimal Control	2 SWS	Lecture /	Hohmann
Exams					
ST 2025	7303183	Optimization of Dynamic Systems			Hohmann

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Assessment
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

T 3.169 Course: Parallel Computing [T-MATH-102271]

Responsible: PD Dr. Mathias Krause
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-101338 - Parallel Computing

Type	Credits	Grading	Version
Oral examination	5 CP	graded	1

T 3.170 Course: Particle Physics I [T-PHYS-102369]

Responsible: Prof. Dr. Torben Ferber
Prof. Dr. Ulrich Husemann
Prof. Dr. Markus Klute
Prof. Dr. Günter Quast
PD Dr. Klaus Rabbertz

Organisation: KIT Department of Physics

Part of: M-PHYS-102114 - Particle Physics I

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Each winter term	1

Events					
WT 25/26	4022031	Particle Physics I	3 SWS	Lecture / 🗣	Klute, Goldenzweig
WT 25/26	4022032	Exercises to Particle Physics I	2 SWS	/ 🗣	Klute, Goldenzweig

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites

none

T 3.171 Course: Pattern Recognition [T-INFO-101362]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Tim Zander
Organisation: KIT Department of Informatics
Part of: M-INFO-100825 - Pattern Recognition

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	2

Events					
ST 2025	24675	Pattern Recognition	4 SWS	Lecture / Practice (/ 🗣	Beyerer
Exams					
ST 2025	7500032	Pattern Recognition			Beyerer

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Pattern Recognition
24675, SS 2025, 4 SWS, Language: German, Open in study portal

Lecture / Practice (VÜ)
On-Site

Organizational issues
Vorlesung: montags 15:45 bis 16:30 Uhr und mittwochs 14:00 bis 15:30 Uhr

Übung: montags 16:30 bis 17:15 Uhr

Literature
Weiterführende Literatur

- Richard O. Duda, Peter E. Hart, Stork G. David. Pattern Classification. Wiley-Interscience, second edition, 2001
- K. Fukunaga. Introduction to Statistical Pattern Recognition. Academic Press, second edition, 1997
- R. Hoffman. Signalanalyse und -erkennung. Springer, 1998
- H. Niemann. Pattern analysis and understanding. Springer, second edition, 1990
- J. Schürmann. Pattern classification. Wiley & Sons, 1996
- S. Theodoridis, K. Koutroumbas. Pattern recognition. London: Academic, 2003
- V. N. Vapnik. The nature of statistical learning theory. Springer, second edition, 2000

T 3.172 Course: Percolation [T-MATH-105869]

Responsible: Prof. Dr. Daniel Hug
Prof. Dr. Günter Last
PD Dr. Steffen Winter

Organisation: KIT Department of Mathematics

Part of: M-MATH-102905 - Percolation

Type	Credits	Grading	Version
Oral examination	5 CP	graded	2

Events					
ST 2025	0117000	Perkolation	2 SWS	Lecture	Last
ST 2025	0117100	Übungen zu 0117000 (Perkolation)	2 SWS	Practice	Last

Prerequisites
none

Workload
150 hours

T 3.173 Course: Physical Foundations of Cryogenics [T-CIWVT-106103]

Responsible: Prof. Dr.-Ing. Steffen Grohmann
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103068 - Physical Foundations of Cryogenics

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2250130	Physical Foundations of Cryogenics	2 SWS	Lecture / 🗣	Grohmann
ST 2025	2250131	Physical Foundations of Cryogenics - Exercises	1 SWS	Practice / 🗣	Grohmann
Exams					
ST 2025	7250130	Physical Foundations of Cryogenics			Grohmann
WT 25/26	7250130	Physical Foundations of Cryogenics			Grohmann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

T 3.174 Course: Poisson Processes [T-MATH-105922]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Daniel Hug
Prof. Dr. Günter Last
Dr. Franz Nestmann
PD Dr. Steffen Winter

Organisation: KIT Department of Mathematics

Part of: M-MATH-102922 - Poisson Processes

Type	Credits	Grading	Version
Oral examination	5 CP	graded	1

Prerequisites
none

Workload
150 hours

T 3.175 Course: Potential Theory [T-MATH-105850]

Responsible: PD Dr. Tilo Arens
Prof. Dr. Roland Griesmaier
PD Dr. Frank Hettlich
Prof. Dr. Wolfgang Reichel

Organisation: KIT Department of Mathematics

Part of: M-MATH-102879 - Potential Theory

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.176 Course: Practical Course: Mathematical and Computational Methods in Robotics and AI [T-INFO-113898]

Responsible: Prof. Dr. Katja Mombaur
Organisation: KIT Department of Informatics
Part of: M-INFO-106933 - Practical Course: Mathematical and Computational Methods in Robotics and AI

Type	Credits	Grading	Recurrence	Version
Examination of another type	6 CP	graded	Each term	1

Events					
ST 2025	2400202	Practical Course: Mathematical and Computational Methods in Robotics & AI	4 SWS	Practical course / 🗣	Mombaur, Große Sundrup
Exams					
ST 2025	7500306	Practical Course: Mathematical and Computational Methods in Robotics and AI			Mombaur

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as an examination of another type (§ 4 Abs. 2 No. 3 SPO).

This includes the preparation of a project report (ca. 10 pages and an oral presentation (30 Min + 15 min questions). Students may withdraw from the examination during the first two weeks after the topic has been communicated.

Prerequisites
Programming skills

Recommendations
Basic mathematical knowledge will be helpful, depending on topic. For Projects in the context of robotics, knowledge of robotics is recommended, but not strictly necessary.

Additional Information
Limited number of projects and participants. Specific project topics will be different each term and will be announced in a presentation during the first semester week or can be indivdually agreed upon with people supervising the practical. Students can propose topics on their own as well.

T 3.177 Course: Probability Theory and Combinatorial Optimization [T-MATH-105923]

Responsible: Prof. Dr. Daniel Hug
Prof. Dr. Günter Last

Organisation: KIT Department of Mathematics

Part of: M-MATH-102947 - Probability Theory and Combinatorial Optimization

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Prerequisites
none

T 3.178 Course: Process Modeling in Downstream Processing [T-CIWVT-106101]

Responsible: apl. Prof. Dr. Matthias Franzreb
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103066 - Process Modeling in Downstream Processing

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Each winter term	1

Events					
ST 2025	2214110	Process Modeling in Downstream Processing	2 SWS	Lecture / 🗣	Franzreb
Exams					
ST 2025	7223015	Process Modeling in Downstream Processing			Franzreb

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 3.179 Course: Processing of Nanostructured Particles [T-CIWVT-106107]

Responsible: Prof. Dr.-Ing. Hermann Nirschl
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103073 - Processing of Nanostructured Particles

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2245030	Processing of Nanostructured Particles	2 SWS	Lecture / 🗣	Nirschl
Exams					
ST 2025	7291921	Processing of Nanostructured Particles			Nirschl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

3.180 Course: Project Lab Scientific Computing [T-MATH-114059]

Responsible: Prof. Dr. Willy Dörfler
Prof. Dr. Marlis Hochbruck
Prof. Dr. Tobias Jahnke
Prof. Dr. Andreas Rieder
Prof. Dr. Christian Wieners

Organisation: KIT Department of Mathematics

Part of: M-MATH-102889 - Introduction to Scientific Computing

Type	Credits	Grading	Version
Coursework	0 CP	pass/fail	1

Exams			
ST 2025	7700153	Project Lab Scientific Computing	Dörich, Hochbruck

T 3.181 Course: Random Graphs and Networks [T-MATH-112241]

Responsible: Prof. Dr. Daniel Hug
Organisation: KIT Department of Mathematics
Part of: M-MATH-106052 - Random Graphs and Networks

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Assessment
oral exam of ca. 30 min

Prerequisites
none

Recommendations
The contents of the module 'Probability Theory' are strongly recommended.

Workload
240 hours

3.182 Course: Real-Time Systems [T-INFO-101340]

Responsible: Prof. Dr.-Ing. Thomas Längle
Organisation: KIT Department of Informatics
Part of: M-INFO-100803 - Real-Time Systems

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

T 3.183 Course: Registration for Certificate Issuance - Supplementary Studies on Science, Technology and Society [T-FORUM-113587]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation: General Studies. Forum Science and Society (FORUM)

Part of: M-FORUM-106753 - Supplementary Studies on Science, Technology and Society

Type	Credits	Grading	Recurrence	Version
Coursework	0 CP	pass/fail	Each term	1

Prerequisites

In order to register, it is mandatory that the basic module and the advanced module have been completed and that the grades for the partial performances in the advanced module are available.

Registration as a partial achievement means the issue of a certificate.

T 3.184 Course: Regularity for Elliptic Operators [T-MATH-113472]

Responsible: apl. Prof. Dr. Peer Kunstmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-106696 - Regularity for Elliptic Operators

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Assessment
oral exam of ca. 30 minutes

Prerequisites
none

Workload
180 hours

T 3.185 Course: Riemann Surfaces [T-MATH-113081]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: M-MATH-106466 - Riemann Surfaces

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	8 CP	graded	Irregular	1 terms	1

Assessment
Oral examination of ca. 30 minutes.

Prerequisites
none

Workload
240 hours

T 3.186 Course: Robotics I - Introduction to Robotics [T-INFO-114190]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-107162 - Robotics I - Introduction to Robotics

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2424152	Robotics I - Introduction to Robotics	4 SWS	Lecture / 🗣	Asfour, Daab, Hyseni
Exams					
ST 2025	7500218	Robotics I - Introduction to Robotics			Asfour

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 120 minutes.

Prerequisites
none.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-108014 - Robotics I - Introduction to Robotics must not have been started.

Below you will find excerpts from events related to this course:

V Robotics I - Introduction to Robotics

2424152, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content

The lecture provides an overview of the fundamentals of robotics using the examples of industrial robots, service robots and autonomous humanoid robots. An insight into all relevant topics is given. This includes methods and algorithms for robot modeling, control and motion planning, image processing and robot programming. First, mathematical basics and methods for kinematic and dynamic robot modeling, trajectory planning and control as well as algorithms for collision-free motion planning and grasp planning are covered. Subsequently, basics of image processing, intuitive robot programming especially by human demonstration and symbolic planning are presented.

In the exercise, the theoretical contents of the lecture are further illustrated with examples. Students deepen their knowledge of the methods and algorithms by independently working on problems and discussing them in the exercise. In particular, students can gain practical programming experience with tools and software libraries commonly used in robotics.

Workload:

Lecture with 3 SWS + 1 SWS Tutorial, 6 LP

6 LP corresponds to 180 hours, including

15 * 3= 45 hours attendance time (lecture)

15 * 1= 15 hours attendance time (tutorial)

15 * 6= 90 hours self-study and exercise sheets

30 hours preparation for the exam

Competency Goals:

The students are able to apply the presented concepts to simple and realistic tasks from robotics. This includes mastering and deriving the mathematical concepts relevant for robot modeling. Furthermore, the students master the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The students know the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. They know algorithms from the field of image processing and are able to apply them to problems in robotics. They are able to model and solve tasks as a symbolic planning problem. The students have knowledge about intuitive programming procedures for robots and know procedures for programming and learning by demonstration.

Organizational issues

The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) usually lasting 120 minutes.

Module for the bachelor and master courses in Informatics,Mechanical Engineering, Mechatronics and Information Technology, Electrical Engineering and Information Technology

Literature

Additional literature:

Fu, Gonzalez, Lee: Robotics - Control, Sensing, Vision, and Intelligence

Russel, Norvig: Artificial Intelligence - A Modern Approach, 2nd. Ed.

T 3.187 Course: Robotics II - Humanoid Robotics [T-INFO-105723]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-102756 - Robotics II - Humanoid Robotics

Type	Credits	Grading	Recurrence	Version
Written examination	3 CP	graded	Each summer term	4

Events					
ST 2025	2400074	Robotics II: Humanoid Robotics	2 SWS	Lecture / 🗣	Asfour, Gao, Krebs
Exams					
ST 2025	7500086	Robotics II: Humanoid Robotics			Asfour

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Recommendations
Having visited the lectures on Robotics I - Introduction to Robotics and Mechano-Informatics and Robotics is recommended.

Below you will find excerpts from events related to this course:

V Robotics II: Humanoid Robotics
2400074, SS 2025, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
The lecture presents current work in the field of humanoid robotics, which deals with the implementation of complex sensorimotor and cognitive abilities. Various methods and algorithm, their advantages and disadvantages, as well as the current state of research are discussed.

The following topics are covered: Applications and real world examples of humanoid robots; biomechanical models of the human body, biologically inspired and data-driven methods of grasping, imitation learning and programming by demonstration; semantic representations of sensorimotor experience as well as cognitive software architectures of humanoid robots

Learning Objectives:

The students have an overview of current research topics in the field of cognitive and learning robotics using the example of humanoid robotics and are able to categorize and assess current developments in the field of cognitive humanoid robotics.

Students are familiar with the main problem areas of cognitive humanoid robotics and are able to develop solutions on the basis of existing research work.

Organizational issues
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) of, in general, 60 minutes.

Workload: 90 h

Recommendations: *Having visited the lectures on Robotics I – Introduction to Robotics and Mechano-Informatics and Robotics is recommended.*

Intended audience: **Module for Mechanical Engineering Master, Mechatronics and Information Technology Master, Electrical Engineering and Information Technology Master**

Literature
Additional literature

Scientific publications on the topic are made available on the lecture website.

T 3.188 Course: Robotics III - Sensors and Perception in Robotics [T-INFO-109931]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-104897 - Robotics III - Sensors and Perception in Robotics

Type	Credits	Grading	Recurrence	Version
Written examination	3 CP	graded	Each summer term	2

Events					
ST 2025	2400067	Robotics III - Sensors and Perception in Robotics	2 SWS	Lecture / 🗣	Asfour, Triebel, Hundhausen
Exams					
ST 2025	7500242	Robotics III - Sensors and Perception in Robotics			Asfour

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
none.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-101352 - Robotics III - Sensors in Robotics must not have been started.

Recommendations
Attending the lecture Robotics I – Introduction to Robotics is recommended.

Below you will find excerpts from events related to this course:

V Robotics III - Sensors and Perception in Robotics
2400067, SS 2025, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
The lecture complements the lecture Robotics I and provides a broad overview of sensors and perception methods used in robotics. The focus is on visual perception, semantic scene interpretation, simultaneous localization and mapping (SLAM) as well as haptic exploration and active perception. The lecture is divided into two parts:

In the first part a comprehensive overview of current sensor technologies is given. A fundamental distinction is made between sensors for the perception of the environment (exteroceptive) and sensors for the perception of the internal state (proprioceptive). The second part of the lecture focuses on the use of exteroceptive sensors in robotics. The topics include tactile exploration and visual data processing, including the basics of feature extraction, segmentation, semantic scene interpretation, simultaneous localization and mapping (SLAM) as well as haptic exploration and active perception.

Learning Obejctives:

Students can name the main sensor principles used in robotics. They can explain the data flow from physical measurement through digitization to the use of the measured sensor data for feature extraction, state estimation and semantic scene understanding.

Students are able to propose and justify suitable sensor concepts for robotic tasks..

Organizational issues
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) of, in general, 60 minutes.

Module for Mechanical Engineering Master, Mechatronics and Information Technology Master, Electrical Engineering and Information Technology Master, Mechatronics and Information Technology Bachelor

Recommendations: **Having visited the lectures on Robotics I – Introduction to Robotics is recommended.**

Workload: 90 h

Literature
Lecture slides will be provided during the course.

Accompanying literature references regarding the individual topics of the lecture will be provided.

T 3.189 Course: Ruin Theory [T-MATH-108400]

Responsible: Prof. Dr. Vicky Fasen-Hartmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-104055 - Ruin Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites
none

T 3.190 Course: Sampling Methods for Machine Learning [T-INFO-114133]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-107090 - Sampling Methods for Machine Learning

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2400194	Sampling Methods for Machine Learning	3 SWS	Lecture / 🗣	Hanebeck, Frisch
Exams					
ST 2025	7500391	Sampling Methods for Machine Learning			Hanebeck

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as an oral examination, lasting 20 minutes in accordance with Section 4 (2) No. 2 SPO.

Prerequisites
Additional certificate for digital exercise (Übungsschein)

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-114134 - Sampling Methods for Machine Learning - Pass must have been started.

Recommendations
Knowledge of a higher programming language with sophisticated libraries for scientific-numerical computing (e.g. Julia, Matlab, Python) is advantageous.

Below you will find excerpts from events related to this course:

V Sampling Methods for Machine Learning

2400194, SS 2025, 3 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
Sample-based inference is the de-facto standard for solving otherwise infeasible problems in machine learning, estimation, and control under (unavoidable) uncertainties. Thus, it is an important foundation for further studies. This lecture gives a thorough overview of state-of-the-art sampling methods and discusses current developments from the research frontier.

The first part shows how to efficiently sample large numbers of random samples from given densities starting with the special cases of uniform and Gaussian distributions. For sampling from arbitrary densities, important techniques such as inverse transform sampling, Knothe-Rosenblatt maps, Markov chain Monte Carlo, normalizing flows, and Langevin equations are introduced.

The second part is concerned with deterministic or low-discrepancy sampling, where the goal is to find a set of representative samples of a given density. These are usually obtained by optimization, which, in contrast to random samples, leads to good coverage, high homogeneity, and reproducible results. To analyze and synthesize such samples, various statistical tests and discrepancy measures are presented. This includes scalar tests such as the Cramér-von Mises test, Kolmogorov-Smirnov test, and multivariate generalizations based on Localized Cumulative Distributions and Stein discrepancy.

Finally, advanced topics such as importance sampling and sampling from the posterior density in a Bayesian update are discussed. Typical applications of sample-based inference include Bayesian neural networks, information fusion, and reinforcement learning.

Organizational issues
In-person lecture and digital/online exercise with ILIAS-Tests.

Appointsments for oral exams: pruefung-isas@iar.kit.edu

T 3.191 Course: Sampling Methods for Machine Learning - Pass [T-INFO-114134]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-107090 - Sampling Methods for Machine Learning

Type	Credits	Grading	Version
Coursework	0 CP	pass/fail	1

Events					
ST 2025	2400194	Sampling Methods for Machine Learning	3 SWS	Lecture / 🗣	Hanebeck, Frisch
Exams					
ST 2025	7500392	Sampling Methods for Machine Learning - Pass			Hanebeck

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Digital exercise:

The assessment is carried out as an examination of another type (§ 4 Abs. 2 No. 3 SPO).

Recommendations
Knowledge of a higher programming language with sophisticated libraries for scientific-numerical computing (e.g. Julia, Matlab, Python) is advantageous

Below you will find excerpts from events related to this course:

V Sampling Methods for Machine Learning

2400194, SS 2025, 3 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
Sample-based inference is the de-facto standard for solving otherwise infeasible problems in machine learning, estimation, and control under (unavoidable) uncertainties. Thus, it is an important foundation for further studies. This lecture gives a thorough overview of state-of-the-art sampling methods and discusses current developments from the research frontier.

The first part shows how to efficiently sample large numbers of random samples from given densities starting with the special cases of uniform and Gaussian distributions. For sampling from arbitrary densities, important techniques such as inverse transform sampling, Knothe-Rosenblatt maps, Markov chain Monte Carlo, normalizing flows, and Langevin equations are introduced.

The second part is concerned with deterministic or low-discrepancy sampling, where the goal is to find a set of representative samples of a given density. These are usually obtained by optimization, which, in contrast to random samples, leads to good coverage, high homogeneity, and reproducible results. To analyze and synthesize such samples, various statistical tests and discrepancy measures are presented. This includes scalar tests such as the Cramér-von Mises test, Kolmogorov-Smirnov test, and multivariate generalizations based on Localized Cumulative Distributions and Stein discrepancy.

Finally, advanced topics such as importance sampling and sampling from the posterior density in a Bayesian update are discussed. Typical applications of sample-based inference include Bayesian neural networks, information fusion, and reinforcement learning.

Organizational issues
In-person lecture and digital/online exercise with ILIAS-Tests.

Appointments for oral exams: pruefung-isas@iar.kit.edu

T 3.192 Course: Scattering Theory [T-MATH-105855]

Responsible: PD Dr. Tilo Arens
Prof. Dr. Roland Griesmaier
PD Dr. Frank Hettlich

Organisation: KIT Department of Mathematics

Part of: M-MATH-102884 - Scattering Theory

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Exams			
ST 2025	7700160	Scattering Theory	Griesmaier

T 3.193 Course: Scattering Theory for Time-dependent Waves [T-MATH-113416]

Responsible: Prof. Dr. Roland Griesmaier
Organisation: KIT Department of Mathematics
Part of: M-MATH-106664 - Scattering Theory for Time-dependent Waves

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Assessment
oral exam of ca. 30 min

Prerequisites
none

Workload
180 hours

T 3.194 Course: Selected Methods in Fluids and Kinetic Equations [T-MATH-111853]

Organisation: KIT Department of Mathematics

Part of: M-MATH-105897 - Selected Methods in Fluids and Kinetic Equations

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	3 CP	graded	Irregular	1 terms	1

Assessment
oral examination of approx. 30 minutes

Prerequisites
none

Recommendations
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

Workload
90 hours

T 3.195 Course: Selected Topics in Harmonic Analysis [T-MATH-109065]

Responsible: Prof. Dr. Dirk Hundertmark
Organisation: KIT Department of Mathematics
Part of: M-MATH-104435 - Selected Topics in Harmonic Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	3 CP	graded	Irregular	1

Prerequisites
none

T 3.196 Course: Self-Booking-HOC-SPZ-FORUM-1-Graded [T-MATH-111515]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Recurrence	Version
Examination of another type	2 CP	graded	Each term	1

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Forum Science and Society (FORUM).

T 3.197 Course: Self-Booking-HOC-SPZ-FORUM-2-Graded [T-MATH-111517]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Recurrence	Version
Examination of another type	2 CP	graded	Each term	1

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Forum Science and Society (FORUM).

T 3.198 Course: Self-Booking-HOC-SPZ-FORUM-5-Ungraded [T-MATH-111516]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Recurrence	Version
Coursework	2 CP	pass/fail	Each term	1

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Placeholder for self-booking of a ungraded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Forum Science and Society (FORUM).

T 3.199 Course: Self-Booking-HOC-SPZ-FORUM-6-Ungraded [T-MATH-111520]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Recurrence	Version
Coursework	2 CP	pass/fail	Each term	1

Self Service Assignment of Supplementary Studies
This course can be used for self service assignment of grades acquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Studium Generale. Forum Wissenschaft und Gesellschaft (FORUM) (ehem. ZAK)

Additional Information
Placeholder for self-booking of an ungraded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Forum Science and Society (FORUM).

T 3.200 Course: Self-Booking-HOC-SPZ-FORUM-PEBA-10-Ungraded [T-MATH-112652]

Organisation: KIT Department of Mathematics

Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Recurrence	Version
Coursework	2 CP	pass/fail	Each term	1

Additional Information

Placeholder for self-booking of a graded interdisciplinary qualification, which was provided at the House of Competence, the "Sprachenzentrum" or the Center for Applied Cultural Studies and Studium Generale.

T 3.201 Course: Self-Booking-HOC-SPZ-FORUM-PEBA-9-Graded [T-MATH-112651]

Organisation: KIT Department of Mathematics

Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading	Version
Examination of another type	2 CP	graded	1

T 3.202 Course: Semigroup Theory for the Navier-Stokes Equations [T-MATH-113415]

Responsible: Dr. rer. nat. Patrick Tolksdorf
Organisation: KIT Department of Mathematics
Part of: M-MATH-106663 - Semigroup Theory for the Navier-Stokes Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Assessment
oral exam of ca. 30 min

Prerequisites
none

Workload
180 hours

T 3.203 Course: Seminar Advanced Topics in Parallel Programming [T-INFO-103584]

Responsible: Prof. Dr. Achim Streit
Organisation: KIT Department of Informatics
Part of: M-INFO-101887 - Seminar Advanced Topics in Parallel Programming

Type	Credits	Grading	Recurrence	Version
Examination of another type	3 CP	graded	Each summer term	1

T 3.204 Course: Seminar Mathematics [T-MATH-105686]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: M-MATH-102730 - Seminar

Type	Credits	Grading	Version
Coursework	3 CP	pass/fail	1

Exams			
ST 2025	7700025	Seminar Mathematics	Kühnlein

T 3.205 Course: Signal Processing Methods [T-ETIT-113837]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106899 - Signal Processing Methods

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2302113	Signal Processing Methods	2 SWS	Lecture / 🗣	Wahls
WT 25/26	2302115	Tutorial to 2302113 Signal Processing Methods	2 SWS	Practice / 🗣	Wahls, Al-Hammadi
Exams					
ST 2025	7302113	Signal Processing Methods			Wahls

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Written exam, approx. 120 minutes.
The module grade is the grade of the written exam.

Prerequisites
none

Recommendations
Familiarity with signals and systems (in particular, Fourier transforms) and probability theory at the Bachelor level is assumed.

T 3.206 Course: Signal Processing with Nonlinear Fourier Transforms and Koopman Operators [T-ETIT-113428]

Responsible: Prof. Dr.-Ing. Sander Wahls
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106675 - Signal Processing with Nonlinear Fourier Transforms and Koopman Operators

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

Events					
ST 2025	2302135	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Lecture / 🗣	Wahls
ST 2025	2302136	Practice to 2302135 Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Practice / 🗣	Wahls, Liang
Exams					
ST 2025	7302135	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators			Wahls

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The examination in this module consists of programming assessments and a graded written examination of 120 minutes.

The programming assignments are either pass or fail. They must be passed during the lecture period for admission to the written examination.

The module grade is the grade of the written exam.

Prerequisites
none

T 3.207 Course: Simulation and Optimization in Robotics and Biomechanics [T-INFO-113123]

Responsible: Prof. Dr. Katja Mombaur
Organisation: KIT Department of Informatics
Part of: M-INFO-106504 - Simulation and Optimization in Robotics and Biomechanics

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each winter term	4

Assessment
The assessment is carried out as an oral examination (§ 4 Abs. 2 No. 1 SPO) lasting up to 30 minutes. It can be repeated once.

As a prerequisite for the participation in the oral exam, students must regularly and successfully participate in the exercises. Students must regularly submit exercise sheets. The number of exercise sheets and the scale for passing will be announced at the beginning of the course.

Prerequisites
Completion of module Robotics 1 or corresponding knowledge required
Programing skills in C/C++

Modeled Prerequisites
The following conditions have to be fulfilled:

1. You have to fulfill one of 2 conditions:
    1. The course T-INFO-101465 - Robotics I - Introduction to Robotics must have been passed.
    2. The course T-INFO-108014 - Robotics I - Introduction to Robotics must have been passed.

Additional Information
Limitation to 30 participants

T 3.208 Course: Sobolev Spaces [T-MATH-105896]

Responsible: Prof. Dr. Roland Schnaubelt
Organisation: KIT Department of Mathematics
Part of: M-MATH-102926 - Sobolev Spaces

Type	Credits	Grading	Version
Oral examination	8 CP	graded	2

Recommendations
Some basic knowledge of (elementary) linear functional analysis is strongly recommended.

T 3.209 Course: Software Engineering II [T-INFO-114259]

Responsible: Prof. Dr.-Ing. Anne Koziolek
Prof. Dr. Raffaela Mirandola
Prof. Dr. Ralf Reussner

Organisation: KIT Department of Informatics

Part of: M-INFO-107235 - Software Engineering II

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each summer term	1

Events					
ST 2025	24076	Software Engineering II	4 SWS	Lecture / 🗣	Reussner, Mirandola, Dehghani
Exams					
ST 2025	7500207	Software Engineering II			Reussner

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 90 minutes.

Prerequisites
None.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-101370 - Software Engineering II must not have been started.

Recommendations
The course *Software Engineering I* should already have been attended.

T 3.210 Course: Space and Time Discretization of Nonlinear Wave Equations [T-MATH-112120]

Responsible: Prof. Dr. Marlis Hochbruck
Organisation: KIT Department of Mathematics
Part of: M-MATH-105966 - Space and Time Discretization of Nonlinear Wave Equations

Type	Credits	Grading	Recurrence	Expansion	Version
Oral examination	6 CP	graded	Irregular	1 terms	1

Prerequisites
none

Workload
180 hours

T 3.211 Course: Spatial Stochastics [T-MATH-105867]

Responsible: Prof. Dr. Daniel Hug
Prof. Dr. Günter Last
PD Dr. Steffen Winter

Organisation: KIT Department of Mathematics

Part of: M-MATH-102903 - Spatial Stochastics

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
WT 25/26	0105600	Spatial Stochastics	4 SWS	Lecture	Last
WT 25/26	0105610	Tutorial for 0105600 (Spatial Stochastics)	2 SWS	Practice	Last

Prerequisites
none

Workload
240 hours

Below you will find excerpts from events related to this course:

V Spatial Stochastics

0105600, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)

Content
Competence Goal:
The students are familiar with some basic spatial stochastic processes. They do not only understand how to deal with general properties of distributions, but also know how to describe and apply specific models (Poisson process, Gaussian random fields). They know how to work self-organised and self-reflexive.

Content:
Random sets
Point processes
Random measures
Palm distributions
Random fields
Gaussian fields
Spectral theory of random fields
Spatial ergodic theorem

Literature
Skriptum/Lectures Notes

T 3.212 Course: Special Topics of Numerical Linear Algebra [T-MATH-105891]

Responsible: PD Dr. Volker Grimm
Prof. Dr. Marlis Hochbruck
PD Dr. Markus Neher

Organisation: KIT Department of Mathematics

Part of: M-MATH-102920 - Special Topics of Numerical Linear Algebra

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
ST 2025	0160400	Topics in Numerical Linear Algebra	4 SWS	Lecture	Neher
Exams					
ST 2025	00068	Special Topics of Numerical Linear Algebra August 18, 2025			Neher
ST 2025	00069	Special Topics of Numerical Linear Algebra Septemver 29/30, 2025			Neher

Prerequisites
none

Workload
240 hours

Below you will find excerpts from events related to this course:

V Topics in Numerical Linear Algebra

Lecture (V)

0160400, SS 2025, 4 SWS, Language: English, Open in study portal

Content
At the end of the course, students possess informed knowledge of methods and concepts of numerical linear algebra for large matrices. For various applications, they choose and implement the right numerical methods and they are able to assess and establish convergence properties of these methods. Students are able to solve problems in a self-organized and reflective manner, and to present and discuss solutions.

- Direct methods for sparse linear systems
- Krylov subspace methods for large linear systems and eigenvalue problems
- Matrix functions

T 3.213 Course: Spectral Theory - Exam [T-MATH-103414]

Responsible: Prof. Dr. Dorothee Frey
PD Dr. Gerd Herzog
apl. Prof. Dr. Peer Kunstmann
Prof. Dr. Roland Schnaubelt
Dr. rer. nat. Patrick Tolksdorf

Organisation: KIT Department of Mathematics

Part of: M-MATH-101768 - Spectral Theory

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
ST 2025	0163700	Spectral Theory	4 SWS	Lecture	Schnaubelt
ST 2025	0163710	Tutorial for 0163700 (Spectral Theory)	2 SWS	Practice	Schnaubelt
Exams					
ST 2025	0100035	Spectral Theory - Exam			Schnaubelt

Assessment
Oral examination of approx. 30 minutes.

Prerequisites
none

Workload
240 hours

Below you will find excerpts from events related to this course:

V Spectral Theory

0163700, SS 2025, 4 SWS, Open in study portal

Lecture (V)

Content
After participation, students understand the concepts of spectrum and resolvent of closed operators on Banach spaces. They will know their basic properties and are able to explain them in simple examples. They can explain and justify the special features of compact operators and the Fredholm Alternative and deduce algebraic identities and norm bounds for operators by means of the Dunford functional calculus and the spectral calculus for self-adjoint operators. This in particular includes spectral projections and spectral mapping theorems. Students are able to apply this general theory to integral and differential equations, and recognize the importance of spectral theoretic methods in Analysis.

Content

- Closed operators on Banach spaces,
- Spectrum and resolvent,
- Compact operators and Fredholm alternative,
- Dunford functional calculus, spectral projections,
- Fourier transform,
- Unbounded self-adjoint operators on Hilbert spaces,
- Spectral theorem,
- Sesquilinear forms and sectorial operators,
- Applications to partial differential equation

Literature

- H.W. Alt: Lineare Funktionalanalysis.
- H. Brezis: Functional Analysis, Sobolev Spaces and Partial Differential Equations.
- J.B. Conway: A Course in Functional Analysis.
- N. Dunford, J.T. Schwartz: Linear Operators, Part I.
- T. Kato: Perturbation Theory of Linear Operators.
- B. Simon: Operator Theory. A Comprehensive Course in Analysis, Part 4.
- A.E. Taylor, D.C. Lay: Introduction to Functional Analysis.
- D. Werner: Funktionalanalysis.

T 3.214 Course: Spectral Theory of Differential Operators [T-MATH-105851]

Responsible: Prof. Dr. Michael Plum
Organisation: KIT Department of Mathematics
Part of: M-MATH-102880 - Spectral Theory of Differential Operators

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.215 Course: Splitting Methods for Evolution Equations [T-MATH-110805]

Responsible: Prof. Dr. Tobias Jahnke
Organisation: KIT Department of Mathematics
Part of: M-MATH-105325 - Splitting Methods for Evolution Equations

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Events					
ST 2025	0160800	Splitting methods for evolution equations	3 SWS	Lecture / 🗣	Jahnke

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

Workload
180 hours

Below you will find excerpts from events related to this course:

V Splitting methods for evolution equations

0160800, SS 2025, 3 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content
Splitting methods are a very popular class of time integrators for solving ordinary or partial differential equations numerically. The underlying idea is to decompose the differential equation into two or more subproblems which can be solved more efficiently than the full problem, and to construct an approximation of the full problem by a suitable composition of the flows of the subproblems.

After a short introduction to splitting methods for ordinary differential equations, the lecture will focus on splitting methods for partial differential equations such as, e.g., linear and nonlinear Schrödinger-type equations and parabolic problems. Special attention will be given to the convergence analysis, in particular to the relation between the order of convergence and the regularity of the data.
This will require some results from semigroup theory, which will be provided in the lecture.

Prerequisites:

Students are expected to be familiar with ordinary differential equations and Runge-Kutta methods (construction, order, stability).

T 3.216 Course: Statistical Learning [T-MATH-111726]

Responsible: Prof. Dr. Mathias Trabs
Organisation: KIT Department of Mathematics
Part of: M-MATH-105840 - Statistical Learning

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Exams			
ST 2025	7700150	Statistical Learning - Exam 1	Klar
ST 2025	7700151	Statistical Learning - Exam 2	Klar
WT 25/26	7700151	Statistical Learning - Exam 3	Klar

Assessment
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Recommendations
The module "Introduction to Stochastics" is recommended. The module "Probability theory" is preferable.

T 3.217 Course: Statistical Thermodynamics [T-CIWVT-106098]

Responsible: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103059 - Statistical Thermodynamics

Type	Credits	Grading	Version
Oral examination	6 CP	graded	1

Events					
ST 2025	2250040	Statistical Thermodynamics	2 SWS	Lecture / 🗣	Enders
ST 2025	2250041	Statistical Thermodynamics - Exercises	1 SWS	Practice / 🗣	Enders
Exams					
ST 2025	7250040	Statistical Thermodynamics			Enders

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
Thermodynamics III

3.218 Course: Steins Method with Applications in Statistics [T-MATH-111187]

Responsible: Dr. rer. nat. Bruno Ebner
Prof. Dr. Daniel Hug

Organisation: KIT Department of Mathematics

Part of: M-MATH-105579 - Steins Method with Applications in Statistics

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites
none

T 3.219 Course: Stochastic Control [T-MATH-105871]

Responsible: Prof. Dr. Nicole Bäuerle
Organisation: KIT Department of Mathematics
Part of: M-MATH-102908 - Stochastic Control

Type	Credits	Grading	Version
Oral examination	4 CP	graded	1

Prerequisites
none

Workload
120 hours

T 3.220 Course: Stochastic Differential Equations [T-MATH-105852]

Responsible: Prof. Dr. Dorothee Frey
Prof. Dr. Roland Schnaubelt

Organisation: KIT Department of Mathematics

Part of: M-MATH-102881 - Stochastic Differential Equations

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.221 Course: Stochastic Geometry [T-MATH-105840]

Responsible: Prof. Dr. Daniel Hug
Prof. Dr. Günter Last
PD Dr. Steffen Winter

Organisation: KIT Department of Mathematics

Part of: M-MATH-102865 - Stochastic Geometry

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

Events					
ST 2025	0152600	Stochastic Geometry	4 SWS	Lecture	Hug
ST 2025	0152610	Tutorial for 0152600 (Stochastic Geometry)	2 SWS	Practice	Hug

Below you will find excerpts from events related to this course:

V Stochastic Geometry

0152600, SS 2025, 4 SWS, Open in study portal

Lecture (V)

Content

For some idea what this course is about see

https://www.math.kit.edu/stoch/seite/raeumstoch-lehre/en

Competence Goals:

The students know the fundamental geometric models and characteristics in stochastic geometry, are familiar with properties of Poisson processes of geometric objects, know examples of applications of models of stochastic geometry, know how to work self-organised and self-reflexive.

Content:

- Random Sets
- Geometric Point Processes
- Stationarity and Isotropy
- Germ Grain Models
- Boolean Models
- Foundations of Integral Geometry
- Geometric densities and characteristics
- Random Tessellations

Literature

Lecture Notes will be provided.

T 3.222 Course: Stochastic Information Processing [T-INFO-101366]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100829 - Stochastic Information Processing

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2424113	Stochastic Information Processing	3 SWS	Lecture / 🗣	Hanebeck
Exams					
ST 2025	7500010	Stochastic Information Processing			Hanebeck

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Stochastic Information Processing

2424113, WS 25/26, 3 SWS, Language: German, Open in study portal

Lecture (V)
On-Site

Content

In order to handle complex dynamic systems (e.g., in robotics), an in-step estimation of the system's internal state (e.g., position and orientation of the actuator) is required. Such an estimation is ideally based on the system model (e.g., a discretized differential equation describing the system dynamics) and the measurement model (e.g., a nonlinear function that maps the state space to a measurement subspace). Both system and measurement model are uncertain (e.g., include additive or multiplicative noise).

For continuous state spaces, an exact calculation of the probability densities is only possible in a few special cases. In practice, general nonlinear systems are often traced back to these special cases by simplifying assumptions. One extreme is linearization with subsequent application of linear estimation theory. However, this often leads to unsatisfactory results and requires additional heuristic measures. At the other extreme are numerical approximation methods, which only evaluate the desired distribution densities at discrete points in the state space. Although the working principle of these procedures is usually quite simple, a practical implementation often turns out to be difficult and especially for higher-dimensional systems it is computationally complex.

As a middle ground, analytical nonlinear estimation methods would therefore often be desirable. In this lecture the main difficulties in the development of such estimation methods are presented and corresponding solution modules are presented. Based on these building blocks, some analytical estimation methods are discussed in detail as examples, which are very suitable for practical implementation and offer a good compromise between computing effort and performance. Useful applications of these estimation methods are also discussed. Both known methods and the results of current research are presented.

Organizational issues

Der Prüfungstermin ist per E-Mail zu vereinbaren. Zusätzliche Anmeldung im CAS nicht vergessen.

Literature

Weiterführende Literatur

Skript zur Vorlesung

T 3.223 Course: Stochastic Simulation [T-MATH-112242]

Responsible: Prof. Dr. Sebastian Krumscheid
Organisation: KIT Department of Mathematics
Part of: M-MATH-106053 - Stochastic Simulation

Type	Credits	Grading	Recurrence	Version
Oral examination	5 CP	graded	Each winter term	1

Events					
WT 25/26	0100027	Stochastic Simulation	2 SWS	Lecture	Krumscheid

Assessment
oral exam of ca. 30 min

Prerequisites
none

Workload
150 hours

Below you will find excerpts from events related to this course:

V Stochastic Simulation

0100027, WS 25/26, 2 SWS, Open in study portal

Lecture (V)

Content
The course covers mathematical concepts and computational tools used to analyze systems with uncertainty arising across various application domains. First, we will address stochastic modelling strategies to represent uncertainty in such systems. Then we will discuss sampling-based methods to assess uncertain system outputs via stochastic simulation techniques. The focus of this course will be on the theoretical foundations of the discussed techniques, as well as their methodological realization as efficient computational tools.

Topics covered include:

- Random variable generation
- Simulation of random processes
- Simulation of Gaussian random fields
- Monte Carlo method; output analysis
- Variance reduction techniques
- Quasi Monte Carlo methods
- Markov Chain Monte Carlo methods (Metropolis-Hasting, Gibbs sampler)

Other topics that may be addressed if time allows, such as rare event simulations, and stochastic optimization using stochastic approximation or simulated annealing.

T 3.224 Course: Structural Graph Theory [T-MATH-111004]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-105463 - Structural Graph Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Prerequisites
none

T 3.225 Course: Technical Optics [T-ETIT-100804]

Responsible: Prof. Dr. Cornelius Neumann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100538 - Technical Optics

Type	Credits	Grading	Recurrence	Version
Written examination	5 CP	graded	Each winter term	1

Events					
WT 25/26	2313720	Technical Optics	2 SWS	Lecture / 🗣	Neumann
WT 25/26	2313722	Technical Optics (Tutorial to 2313720)	1 SWS	Practice / 🗣	Neumann
Exams					
ST 2025	7313720	Technical Optics			Neumann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.226 Course: Technomathematical Seminar [T-MATH-105884]

Responsible: Prof. Dr. Tobias Jahnke
PD Dr. Stefan Kühnlein

Organisation: KIT Department of Mathematics

Part of: M-MATH-102863 - Technomathematical Seminar

Type	Credits	Grading	Version
Coursework	3 CP	pass/fail	1

Exams			
ST 2025	7700056	Technomathematical Seminar	Kühnlein

T 3.227 Course: Telematics [T-INFO-114269]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: M-INFO-107243 - Telematics

Type	Credits	Grading	Recurrence	Version
Written examination	6 CP	graded	Each winter term	1

Events					
WT 25/26	2400007	Telematics	4 SWS	Lecture / 🗣	Zitterbart, Helmig, Mahrt, Seehofer
Exams					
ST 2025	7500098	Telematics			Zitterbart

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 90 minutes.

Depending on the number of participants, it will be announced six weeks before the examination (Section 6 (3) SPO) whether the assessment will take the form of an oral examination of approx.

- in the form of an oral examination of approx. 30 minutes in accordance with § 4 Para. 2 No. 2 SPO ***or***

- in the form of a written examination in accordance with § 4 Para. 2 No. 1 SPO

takes place.

Prerequisites
None.

Modeled Prerequisites
The following conditions have to be fulfilled:

1. The course T-INFO-101338 - Telematics must not have been started.

Recommendations

- Contents of the lecture ***Introduction to computer networks***or comparable lectures are a prerequisite.
- Attendance of the module-accompanying ***basic practical course Protocol Engineering*** is recommended.

Below you will find excerpts from events related to this course:

V Telematics
2400007, WS 25/26, 4 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

Content

The lecture covers (i.a.) protocols, architectures, as well as methods and algorithms, for routing and establishing reliable end-to-end connections in the Internet. In addition to various methods for media access control in local area networks, the lecture also covers other communication systems, e.g. circuit-switched systems such as ISDN. Participants should also have understood the possibilities for managing and administering networks.

Familiary with the contents of the lecture *Einführung in Rechnernetze* or comparable lectures is assumed.

Learning Objectives

After attending this lecture, the students will

- have a profound understanding of protocols, architectures, as well as procedures and algorithms used for routing and for establishing reliable end-to-end connections in the Internet
- have a profound understanding of different media access control procedures in local networks and other communication systems like circuit-switched ISDN
- have a profound understanding of the problems that arise in large scale dynamic communication systems and are familiar with mechanism to deal with these problems
- be familiar with current developments such as SDN and data center networking
- be familiar with different aspects and possibilities for network management and administration

Students have a profound understanding of the basic protocol mechanisms that are necessary to establish reliable end-to-end communication. Students have detailed knowledge about the congestion and flow control mechanisms used in TCP and can discuss fairness issue in the context of multiple parallel transport streams. Students can analytically determine the performance of transport protocols and know techniques for dealing with specific constraints in the context of TCP, e.g., high data rates and low latencies. Students are familiar with current topics such as the problem of middle boxes on the Internet, the usage of TCP in data centers or multipath TCP. Students are also familiar with practical aspects of modern transport protocols and know practical ways to overcome heterogeneity in the development of distributed applications.

Students know the functions of (Internet) routing and routers and can explain and apply common routing algorithms. Students are familiar with routing architectures and different alternatives for buffer placement as well as their advantages and disadvantages. Students understand the classification into interior and exterior gateway protocols and have in-depth knowledge of the functionality and features of common protocols such as RIP, OSPF, and BGP. Students are also familiar with current topics such as label switching, IPv6 and SDN.

Students know the function of media access control and are able to classify and analytically evaluate different media access control mechanisms. Students have an in-depth knowledge of Ethernet and various Ethernet variants and characteristics, which especially includes current developments such as real-time Ethernet and data center Ethernet. Students can explain and apply the Spanning Tree Protocol.

Students know the architecture of ISDN and can reproduce the peculiarities of setting up the ISDN subscriber line. Students are familiar with the technical features of DSL.

Literature

S. Keshav. An Engineering Approach to Computer Networking. Addison-Wesley, 1997 J.F. Kurose, K.W. Ross. Computer Networking: A Top-Down Approach Featuring the Internet. 4rd Edition, Addison-Wesley, 2007 W. Stallings. Data and Computer Communications. 8th Edition, Prentice Hall, 2006 Weiterführende Literatur •D. Bertsekas, R. Gallager. Data Networks. 2nd Edition, Prentice-Hall, 1991 •F. Halsall. Data Communications, Computer Networks and Open Systems. 4th Edition, Addison-Wesley Publishing Company, 1996 •W. Haaß. Handbuch der Kommunikationsnetze. Springer, 1997 •A.S. Tanenbaum. Computer-Networks. 4th Edition, Prentice-Hall, 2004 •Internet-Standards •Artikel in Fachzeitschriften

T 3.228 Course: Theoretical Nanooptics [T-PHYS-104587]

Responsible: Prof. Dr. Markus Garst
Prof. Dr. Carsten Rockstuhl
Organisation: KIT Department of Physics
Part of: M-PHYS-102295 - Theoretical Nanooptics

Type	Credits	Grading	Version
Oral examination	6 CP	graded	2

T 3.229 Course: Theoretical Optics [T-PHYS-104578]

Responsible: PD Dr. Boris Narozhnyy
Prof. Dr. Carsten Rockstuhl

Organisation: KIT Department of Physics

Part of: M-PHYS-102277 - Theoretical Optics

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Each summer term	1

Events					
ST 2025	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2025	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, NN

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.230 Course: Thermodynamics III [T-CIWVT-106033]

Responsible: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103058 - Thermodynamics III

Type	Credits	Grading	Version
Written examination	6 CP	graded	1

Events					
WT 25/26	2250030	Thermodynamics III	2 SWS	Lecture / 🗣	Enders
WT 25/26	2250031	Thermodynamics III - Exercises	1 SWS	Practice / 🗣	Enders, und Mitarbeitende
Exams					
ST 2025	7250030	Thermodynamics III			Enders

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Learning control is a written examination lasting 90 minutes.

Prerequisites
None

T 3.231 Course: Thermodynamics of Interfaces [T-CIWVT-106100]

Responsible: Prof. Dr. Sabine Enders
Organisation: KIT Department of Chemical and Process Engineering
Part of: M-CIWVT-103063 - Thermodynamics of Interfaces

Type	Credits	Grading	Version
Oral examination	4 CP	graded	2

Events					
ST 2025	2250050	Thermodynamics of Interfaces	2 SWS	Lecture / 🗣	Enders
Exams					
ST 2025	7250050	Thermodynamics of Interfaces			Enders

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Assessment
Erfolgskontrolle ist eine mündliche Prüfung im Umfang von 30 Minuten.

T 3.232 Course: Time Series Analysis [T-MATH-105874]

Responsible: Dr. rer. nat. Bruno Ebner
Prof. Dr. Vicky Fasen-Hartmann
Prof. Dr. Tilmann Gneiting
PD Dr. Bernhard Klar
Prof. Dr. Mathias Trabs

Organisation: KIT Department of Mathematics

Part of: M-MATH-102911 - Time Series Analysis

Type	Credits	Grading	Version
Oral examination	4 CP	graded	4

Events					
ST 2025	0161100	Time Series Analysis	2 SWS	Lecture	Fasen-Hartmann
ST 2025	0161110	Tutorial for 0161100 (Time Series Analysis)	1 SWS	Practice	Fasen-Hartmann
Exams					
ST 2025	7700097	Time Series Analysis			Fasen-Hartmann
ST 2025	7700099	Time Series Analysis			Fasen-Hartmann
ST 2025	7700108	Time Series Analysis			Fasen-Hartmann

Workload
120 hours

Below you will find excerpts from events related to this course:

V Time Series Analysis

0161100, SS 2025, 2 SWS, Language: English, Open in study portal

Lecture (V)

Content
A time series is a sequence of data sequentially observed in time. This course provides an introduction to the theory and practice of statistical time series analysis. The content is as follows:

- Stationary time series
- Trends and seasonality
- Autocorrelation
- Autoregressive models
- ARMA models
- Parameter estimation
- Forecasting
- Spectral density and periodogram

T 3.233 Course: Topics in Algebraic Topology [T-MATH-114063]

Responsible: TT-Prof. Dr. Manuel Krannich
Organisation: KIT Department of Mathematics
Part of: M-MATH-107017 - Topics in Algebraic Topology

Type	Credits	Grading	Recurrence	Expansion	Version
Written examination	6 CP	graded	Irregular	1 terms	1

Exams			
ST 2025	7700155	Topics in Algebraic Topology	Krannich

Assessment
written exam (120 min.)

Prerequisites
none

Workload
180 hours

T 3.234 Course: Topics in Homotopy Theory [T-MATH-114682]

Responsible: TT-Prof. Dr. Manuel Krannich
Organisation: KIT Department of Mathematics
Part of: M-MATH-107484 - Topics in Homotopy Theory

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

Workload
180 hours

T 3.235 Course: Topological Data Analysis [T-MATH-111031]

Responsible: Prof. Dr. Tobias Hartnick
Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: M-MATH-105487 - Topological Data Analysis

Type	Credits	Grading	Recurrence	Version
Oral examination	6 CP	graded	Irregular	1

Prerequisites
none

T 3.236 Course: Translation Surfaces [T-MATH-112128]

Responsible: Prof. Dr. Frank Herrlich
Organisation: KIT Department of Mathematics
Part of: M-MATH-105973 - Translation Surfaces

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Prerequisites
none

Workload
240 hours

T 3.237 Course: Traveling Waves [T-MATH-105897]

Responsible: Dr. Björn de Rijk
Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-102927 - Traveling Waves

Type	Credits	Grading	Version
Oral examination	6 CP	graded	2

Assessment
The module examination takes place in form of an oral exam of about 30 minutes. Please see under "Modulnote" for more information about the bonus regulation.

Prerequisites
none

Recommendations
The following background is strongly recommended: Analysis 1-4.

Workload
180 hours

T 3.238 Course: Uncertainty Quantification [T-MATH-108399]

Responsible: Prof. Dr. Martin Frank
Organisation: KIT Department of Mathematics
Part of: M-MATH-104054 - Uncertainty Quantification

Type	Credits	Grading	Recurrence	Version
Oral examination	4 CP	graded	Irregular	1

Events					
ST 2025	0164400	Uncertainty Quantification	2 SWS	Lecture	Frank
ST 2025	0164410	Tutorial for 0164400 (Uncertainty quantification)	1 SWS	Practice	Frank
Exams					
ST 2025	7700045	Uncertainty Quantification			Frank

Prerequisites
none

Below you will find excerpts from events related to this course:

V Uncertainty Quantification

0164400, SS 2025, 2 SWS, Language: English, Open in study portal

Lecture (V)

Content
"There are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – there are things we do not know we don’t know." (Donald Rumsfeld)

In this class, we learn to deal with the known unknowns, a field called Un- certainty Quantification (UQ). We particularly focus on the propagation of uncertainties (e.g. unknown data, unknown initial or boundary conditions) through models (mostly differential equations) and leave other important questions of UQ (especially inference) aside. Given uncertain input, how un- certain is the output? The uncertainties are modeled as random variables, and thus the solutions of the equations become random variables themselves.

Thus we summarize the necessary foundations of probability theory, with a focus on modeling correlated and uncorrelated random vectors. Further- more, we will see that every uncertain parameter becomes a dimension in the problem. We are thus quickly led to high-dimensional problems. Standard numerical methods suffer from the so-called curse of dimensionality, i.e. to reach a certain accuracy one needs excessively many model evaluations. Thus we study the fundamentals of approximation theory.

The first part of the course ("how to do it") gives an overview on techniques that are used. Among these are:

- Sensitivity analysis
- Monte-Carlo methods
- Spectral expansions
- Stochastic Galerkin method
- Collocation methods, sparse grids

The second part of the course ("why to do it like this") deals with the theoretical foundations of these methods. The so-called "curse of dimensionality" leads us to questions from approximation theory. We look back at the very standard numerical algorithms of interpolation and quadrature, and ask how they perform in many dimensions.

Organizational issues
The course will be offered in flipped classroom format. This means that the lectures will be made available as videos; students will also have lecture notes. We meet in presence for the tutorials, and there will also be office hours.

Literature

- R.C. Smith: Uncertainty Quantification: Theory, Implementation, and Applications, SIAM, 2014.
- T.J. Sullivan: Introduction to Uncertainty Quantification, Springer-Verlag, 2015.
- D. Xiu: Numerical Methods for Stochastic Computations, Princeton University Press, 2010.
- O.P. Le Maître, O.M. Knio: Spectral Methods for Uncertainty Quantification, Springer-Verlag, 2010.
- R. Ghanem, D. Higdon, H. Owhadi:Handbook of Uncertainty Quantification, Springer-Verlag, 2017.

3.239 Course: Variational Methods [T-MATH-110302]

Responsible: Prof. Dr. Wolfgang Reichel
Organisation: KIT Department of Mathematics
Part of: M-MATH-105093 - Variational Methods

Type	Credits	Grading	Version
Oral examination	8 CP	graded	1

T 3.240 Course: Wavelets [T-MATH-105838]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102895 - Wavelets

Type	Credits	Grading	Recurrence	Version
Oral examination	8 CP	graded	Irregular	1

Assessment
Mündliche Prüfung im Umfang von ca. 30 Minuten.

Prerequisites
none

Workload
240 hours