Karlsruher Institut für Technologie

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

SPO 2016

Summer term 2024

Date: 05/03/2024

KIT DEPARTMENT OF MATHEMATICS

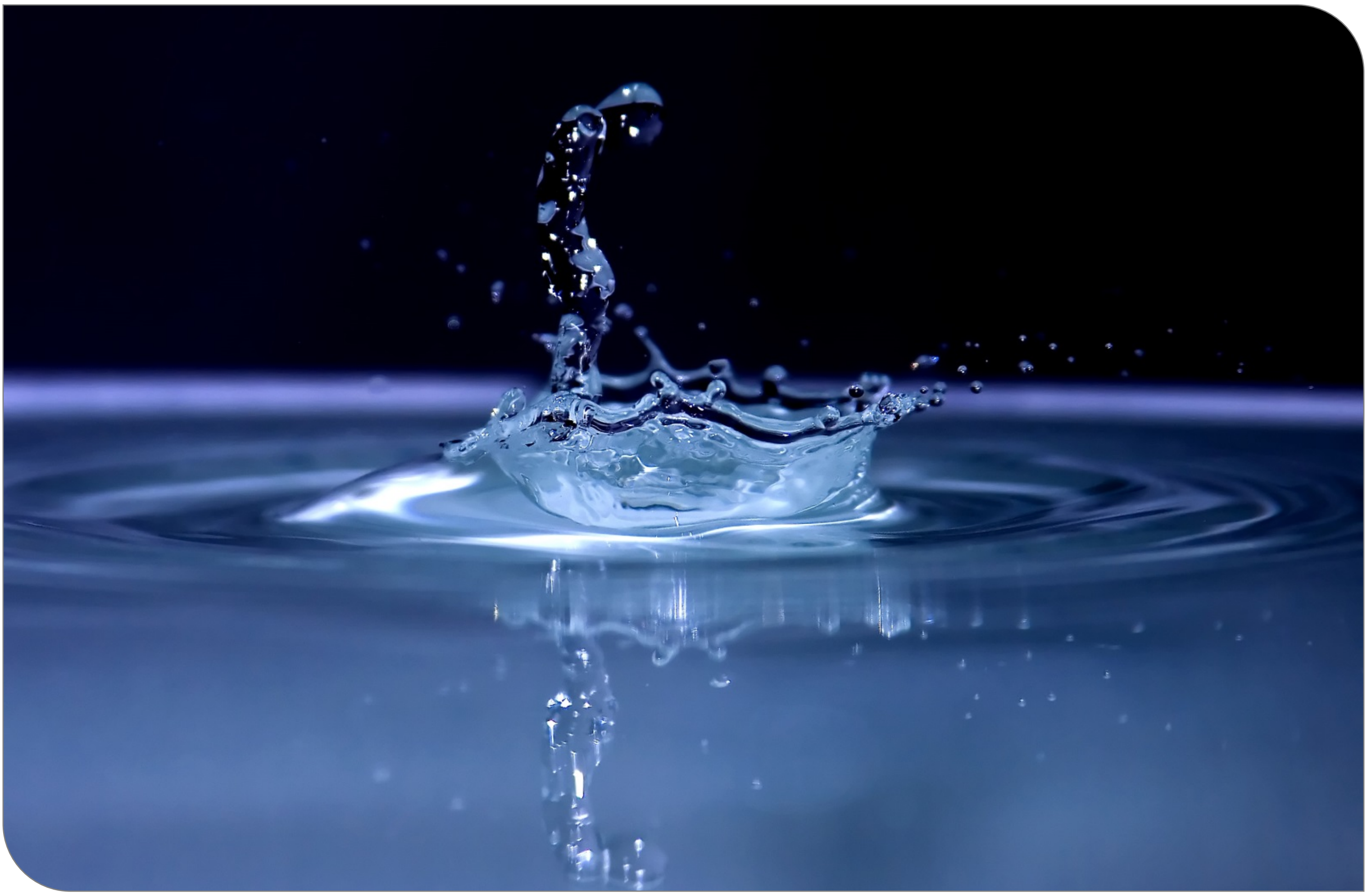

Table Of Contents

1 Field of study structure

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

1.2 Internship

Credits
10

Mandatory		
M-MATH-102861	Internship	10 CR

1.3 Applied Mathematics

Credits
24

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

M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR
Elective Field Applied Mathematics (Election: at least 8 credits)		
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-101315	Algebra	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102905	Percolation	5 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-101317	Differential Geometry	8 CR

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

M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

1.4 Electrical Engineering / Information Technology

Credits
18-27

Mandatory		
M-MATH-102863	Technomathematical Seminar	3 CR
Electrical Engineering / Information Technology (Election: between 15 and 24 credits)		
M-ETIT-102310	Optimal Control and Estimation	3 CR
M-ETIT-100371	Nonlinear Control Systems	3 CR
M-ETIT-106449	Medical Imaging Technology I	3 CR
M-ETIT-106670	Medical Imaging Technology II neu	3 CR
M-ETIT-100386	Electromagnetics and Numerical Calculation of Fields	4 CR
M-ETIT-100506	Optical Waveguides and Fibers	4 CR
M-ETIT-100531	Optimization of Dynamic Systems	5 CR
M-ETIT-100532	Batteries and Fuel Cells	5 CR
M-ETIT-100538	Technical Optics	5 CR
M-ETIT-100540	Methods of Signal Processing	6 CR
M-ETIT-106675	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators neu	6 CR

1.5 Experimental Physics

Credits
18-27

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

1.6 Chemical and Process Engineering

Credits
18-27

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

1.7 Wildcard Technical Field

Credits
18-27

Mandatory		
M-MATH-102863	Technomathematical Seminar	3 CR

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	6 CR
M-INFO-100801	Telematics	6 CR
M-INFO-100803	Real-Time Systems	6 CR
M-INFO-104897	Robotics III - Sensors and Perception in Robotics	3 CR
M-INFO-100818	Computer Architecture	6 CR
M-INFO-100819	Cognitive Systems	6 CR
M-INFO-100825	Pattern Recognition	6 CR
M-INFO-100833	Software Engineering II	6 CR
M-INFO-100846	Neural Networks	6 CR
M-INFO-100856	Computer Graphics	6 CR
M-INFO-100893	Robotics I - Introduction to Robotics	6 CR
M-INFO-100840	Localization of Mobile Agents	6 CR
M-INFO-100839	Fuzzy Sets	6 CR
M-INFO-101887	Seminar Advanced Topics in Parallel Programming	3 CR
M-INFO-104460	Deep Learning and Neural Networks	6 CR
M-INFO-100829	Stochastic Information Processing	6 CR
M-INFO-106014	Introduction to Artificial Intelligence	5 CR
M-INFO-106015	Information Security	5 CR
M-INFO-102756	Robotics II - Humanoid Robotics	3 CR
M-INFO-106315	IT Security neu	6 CR

1.9 Mathematical Specialization

Credits
19

Mandatory		
M-MATH-102730	Seminar	3 CR
Elective Field Mathematical Specialization (Election: at least 16 credits)		
M-MATH-102864	Convex Geometry	8 CR
M-MATH-102866	Geometry of Schemes	8 CR
M-MATH-102872	Evolution Equations	8 CR
M-MATH-102879	Potential Theory	8 CR
M-MATH-102883	Computer-Assisted Analytical Methods for Boundary and Eigenvalue Problems	8 CR
M-MATH-102888	Numerical Methods for Differential Equations	8 CR
M-MATH-102890	Inverse Problems	8 CR
M-MATH-102898	Multigrid and Domain Decomposition Methods	4 CR
M-MATH-102904	Brownian Motion	4 CR
M-MATH-102906	Generalized Regression Models	4 CR
M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-101315	Algebra	8 CR
M-MATH-101724	Algebraic Geometry	8 CR
M-MATH-101725	Algebraic Number Theory	8 CR
M-MATH-101768	Spectral Theory	8 CR
M-MATH-102867	Geometric Group Theory	8 CR
M-MATH-102874	Integral Equations	8 CR
M-MATH-102876	Boundary value problems for nonlinear differential equations	8 CR
M-MATH-102881	Stochastic Differential Equations	8 CR
M-MATH-102894	Numerical Methods in Computational Electrodynamics	6 CR
M-MATH-102899	Optimisation and Optimal Control for Differential Equations	4 CR
M-MATH-102905	Percolation	5 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-101317	Differential Geometry	8 CR
M-MATH-101320	Functional Analysis	8 CR
M-MATH-101336	Graph Theory	8 CR
M-MATH-101338	Parallel Computing	5 CR
M-MATH-102865	Stochastic Geometry	8 CR
M-MATH-102870	Classical Methods for Partial Differential Equations	8 CR
M-MATH-102871	Boundary and Eigenvalue Problems	8 CR
M-MATH-102878	Complex Analysis	8 CR
M-MATH-102885	Maxwell's Equations	8 CR

M-MATH-102889	Introduction to Scientific Computing	8 CR
M-MATH-102895	Wavelets	8 CR
M-MATH-102900	Adaptive Finite Elemente Methods	6 CR
M-MATH-102903	Spatial Stochastics	8 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-102860	Continuous Time Finance	8 CR
M-MATH-102868	Modular Forms	8 CR
M-MATH-102869	Geometric Group Theory II	8 CR
M-MATH-102875	Models of Mathematical Physics	8 CR
M-MATH-102877	Nonlinear Evolution Equations	8 CR
M-MATH-102884	Scattering Theory	8 CR
M-MATH-102886	Nonlinear Functional Analysis	3 CR
M-MATH-102887	Monotonicity Methods in Analysis	3 CR
M-MATH-102897	Mathematical Methods in Signal and Image Processing	8 CR
M-MATH-102901	Numerical Methods in Mathematical Finance	8 CR
M-MATH-102907	Markov Decision Processes	5 CR
M-MATH-102908	Stochastic Control	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-102880	Spectral Theory of Differential Operators	8 CR
M-MATH-102892	Numerical Optimisation Methods	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-103080	Dynamical Systems	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-103527	Foundations of Continuum Mechanics	3 CR
M-MATH-103539	Nonlinear Analysis	8 CR
M-MATH-103700	Exponential Integrators	6 CR
M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR

M-MATH-104055	Ruin Theory	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105764	Numerical Analysis of Helmholtz Problems	3 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR
M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106466	Riemann Surfaces	8 CR
M-MATH-106473	Ergodic Theory	8 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106632	Curves on Surfaces neu	3 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR

M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR
M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

1.10 Interdisciplinary Qualifications

Credits
2

Interdisciplinary Qualifications (Election: at least 2 credits)		
M-MATH-102994	Key Competences	2 CR

1.11 Additional Examinations

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

M-MATH-102909	Mathematical Statistics	8 CR
M-MATH-102910	Nonparametric Statistics	4 CR
M-MATH-102911	Time Series Analysis	4 CR
M-MATH-102912	Global Differential Geometry	8 CR
M-MATH-102913	Banach Algebras	3 CR
M-MATH-102915	Numerical Methods for Hyperbolic Equations	6 CR
M-MATH-102918	Internet Seminar for Evolution Equations	8 CR
M-MATH-102919	Discrete Time Finance	8 CR
M-MATH-102920	Special Topics of Numerical Linear Algebra	8 CR
M-MATH-102921	Geometric Numerical Integration	6 CR
M-MATH-102922	Poisson Processes	5 CR
M-MATH-102923	Geometric Analysis	8 CR
M-MATH-102924	Optimization in Banach Spaces	5 CR
M-MATH-102926	Sobolev Spaces	8 CR
M-MATH-102927	Traveling Waves	6 CR
M-MATH-102928	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR
M-MATH-102929	Mathematical Modelling and Simulation in Practise	4 CR
M-MATH-102930	Numerical Methods for Integral Equations	8 CR
M-MATH-102931	Numerical Methods for Maxwell's Equations	6 CR
M-MATH-102932	Numerical Methods in Fluid Mechanics	4 CR
M-MATH-102935	Compressive Sensing	5 CR
M-MATH-102936	Functions of Operators	6 CR
M-MATH-102937	Functions of Matrices	8 CR
M-MATH-106634	Computational Fluid Dynamics and Simulation Lab neu	4 CR
M-MATH-102939	Extreme Value Theory	4 CR
M-MATH-102940	Comparison Geometry	5 CR
M-MATH-102941	Control Theory	6 CR
M-MATH-102943	Introduction into Particulate Flows	3 CR
M-MATH-102947	Probability Theory and Combinatorial Optimization	8 CR
M-MATH-102948	Algebraic Topology	8 CR
M-MATH-102949	Introduction to Geometric Measure Theory	6 CR
M-MATH-102950	Combinatorics	8 CR
M-MATH-102952	L2-Invariants	5 CR
M-MATH-102953	Algebraic Topology II	8 CR
M-MATH-102954	Group Actions in Riemannian Geometry	5 CR
M-MATH-102955	Advanced Inverse Problems: Nonlinearity and Banach Spaces	5 CR
M-MATH-102956	Forecasting: Theory and Practice	8 CR
M-MATH-102957	Extremal Graph Theory	4 CR
M-MATH-102959	Homotopy Theory	8 CR
M-MATH-103259	Bifurcation Theory	5 CR
M-MATH-103260	Mathematical Methods of Imaging	5 CR
M-MATH-103251	Aspects of Geometric Analysis	4 CR
M-MATH-104054	Uncertainty Quantification	4 CR
M-MATH-104055	Ruin Theory	4 CR
M-MATH-104057	Key Moments in Geometry	5 CR
M-MATH-104058	Numerical Linear Algebra in Image Processing	6 CR
M-MATH-104059	Mathematical Topics in Kinetic Theory	4 CR
M-MATH-103527	Foundations of Continuum Mechanics	3 CR
M-MATH-103539	Nonlinear Analysis	8 CR
M-MATH-103700	Exponential Integrators	6 CR

M-MATH-103709	Numerical Linear Algebra for Scientific High Performance Computing	5 CR
M-MATH-103919	Introduction to Kinetic Theory	4 CR
M-MATH-104261	Lie Groups and Lie Algebras	8 CR
M-MATH-104349	Bott Periodicity	5 CR
M-MATH-104425	Dispersive Equations	6 CR
M-MATH-104435	Selected Topics in Harmonic Analysis	3 CR
M-MATH-104827	Fourier Analysis and its Applications to PDEs	6 CR
M-MATH-103540	Boundary Element Methods	8 CR
M-MATH-105066	Nonlinear Maxwell Equations	8 CR
M-MATH-105101	Introduction to Homogeneous Dynamics	6 CR
M-MATH-105093	Variational Methods	8 CR
M-MATH-105324	Harmonic Analysis	8 CR
M-MATH-105325	Splitting Methods for Evolution Equations	6 CR
M-MATH-105326	Nonlinear Wave Equations	4 CR
M-MATH-105327	Numerical Simulation in Molecular Dynamics	8 CR
M-MATH-105331	Introduction to Aperiodic Order	3 CR
M-MATH-105432	Discrete Dynamical Systems	3 CR
M-MATH-105463	Structural Graph Theory	4 CR
M-MATH-105487	Topological Data Analysis	6 CR
M-MATH-105579	Steins Method with Applications in Statistics	4 CR
M-MATH-105636	Analytical and Numerical Homogenization	6 CR
M-MATH-105649	Fractal Geometry	6 CR
M-MATH-105650	Introduction to Fluid Dynamics	3 CR
M-MATH-105651	Applications of Topological Data Analysis	4 CR
M-MATH-105837	Introduction to Kinetic Equations	3 CR
M-MATH-105838	Introduction to Microlocal Analysis	3 CR
M-MATH-105839	Lie-Algebras (Linear Algebra 3)	8 CR
M-MATH-105840	Statistical Learning	8 CR
M-MATH-105897	Selected Methods in Fluids and Kinetic Equations	3 CR
M-MATH-105931	Metric Geometry	8 CR
M-MATH-105964	Introduction to Convex Integration	3 CR
M-MATH-105966	Space and Time Discretization of Nonlinear Wave Equations	6 CR
M-MATH-105973	Translation Surfaces	8 CR
M-MATH-106045	Introduction to Stochastic Differential Equations	4 CR
M-MATH-106052	Random Graphs and Networks	8 CR
M-MATH-106053	Stochastic Simulation	5 CR
M-MATH-106063	Numerical Complex Analysis	6 CR
M-MATH-106064	Topological Genomics	3 CR
M-ZAK-106099	Supplementary Studies on Sustainable Development	19 CR
M-ZAK-106235	Supplementary Studies on Culture and Society	22 CR
M-MATH-106328	Bayesian Inverse Problems with Connections to Machine Learning	4 CR
M-MATH-106401	Introduction to Fluid Mechanics	6 CR
M-MATH-106466	Riemann Surfaces	8 CR
M-MATH-106473	Ergodic Theory	8 CR
M-MATH-106485	Functional Data Analysis	4 CR
M-MATH-106486	Harmonic Analysis 2	8 CR
M-MATH-106591	Introduction to Dynamical Systems	6 CR
M-MATH-106632	Curves on Surfaces neu	3 CR
M-MATH-106640	Modelling and Simulation of Lithium-Ion Batteries neu	4 CR
M-MATH-106664	Scattering Theory for Time-dependent Waves neu	6 CR

M-MATH-106667	Geometric Variational Problems neu	8 CR
M-MATH-106666	Minimal Surfaces neu	3 CR
M-MATH-106663	Semigroup Theory for the Navier-Stokes Equations neu	6 CR
M-MATH-106696	Regularity for Elliptic Operators neu	6 CR
M-MATH-106695	Numerical Analysis of Neural Networks neu	6 CR
M-MATH-106682	Numerical Methods for Oscillatory Differential Equations neu	8 CR

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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105898	Adaptive Finite Element Methods	6 CR	Dörfler

Competence Certificate
oral exam of ca. 25 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 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

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

Recommendation
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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

Recommendation
Inverse problems, Functional analysis

M 2.3 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	2

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

Competence Certificate
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.

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

Recommendation
Basic knowledge on groups and rings is benefitial.

M 2.4 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

2.5 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

M 2.6 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105915	Algebraic Topology	8 CR	Krannich, Sauer

Prerequisites
none

M 2.7 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105926	Algebraic Topology II	8 CR	Sauer

Prerequisites
none

M 2.8 Module: Analytical and Numerical Homogenization [M-MATH-105636]

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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

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

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 the solution of multiscale problems and from homogenization theory. In addition, they know methods for the numerical approximation of multiscale and the homogenized solution. They are able to analyze the convergence of these methods and asses the pros and cons 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. local orthogonal decomposition)

Annotation
Upon request the lecture will be held in english.

M 2.9 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

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

Prerequisites
None

2.10 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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.

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

2.11 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

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

Competence Certificate
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)

Recommendation
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)

2.12 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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105886	Banach Algebras	3 CR	Herzog

Competence Certificate
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

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

2.13 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

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

Competence Certificate
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)

Recommendation
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 2.14 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

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

Competence Certificate
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)

Recommendation
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: Batteries and Fuel Cells [M-ETIT-100532]

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 scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	2

Mandatory			
T-ETIT-100983	Batteries and Fuel Cells	5 CR	Krewer

Prerequisites
none

M 2.16 Module: Bayesian Inverse Problems with Connections to Machine Learning [M-MATH-106328]

Responsible: TT-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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

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

Competence Certificate
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

Recommendation
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.

M 2.17 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-106487	Bifurcation Theory	5 CR	Mandel

Prerequisites
None

Annotation
Course is held in English

2.18 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

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

Competence Certificate
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

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

Literature
Vorlesungsskript

M 2.19 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-108905	Bott Periodicity	5 CR	Tuschmann

Prerequisites
None

2.20 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

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

Competence Certificate
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

2.21 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

M 2.22 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

2.23 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

Recommendation
The course 'Probability Theory' is strongly recommended.

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

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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

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

M 2.25 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

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

M 2.26 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	English	4	3

Mandatory			
T-MATH-105916	Combinatorics	8 CR	Aksenovich

Competence Certificate
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.

Annotation

- Regular cycle: every 2nd year, summer semester
- Course is held in English

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

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

M 2.27 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106104	Combustion Technology	6 CR	Trimis

Competence Certificate
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

M 2.28 Module: Comparison Geometry [M-MATH-102940]

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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105917	Comparison Geometry	5 CR	Tuschmann

Prerequisites
none

M 2.29 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

2.30 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105894	Compressive Sensing	5 CR	Rieder

Competence Certificate
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

Recommendation
The course "Introduction to stochastics" is recommended.

M 2.31 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

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

Competence Certificate
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 2.32 Module: Computational Fluid Dynamics and Simulation Lab [M-MATH-106634]

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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German/English	4	2

Mandatory			
T-MATH-113373	Computational Fluid Dynamics and Simulation Lab	4 CR	Krause, Thäter

Competence Certificate
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

Recommendation
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 2.33 Module: Computer Architecture [M-INFO-100818]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101355	Computer Architecture	6 CR	Karl

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

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

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

2.35 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

M 2.36 Module: Condensed Matter Theory I, Fundamentals [M-PHYS-102054]

Responsible: 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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).

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

Responsible: 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 scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each winter term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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)

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

Responsible: Prof. Dr. Markus Garst
PD 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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).

Recommendation
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.

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

Responsible: Prof. Dr. Markus Garst
PD 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 scale	Recurrence	Duration	Language	Level	Version
12	Grade to a tenth	Each summer term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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)

Recommendation
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.

M 2.40 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

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

Competence Certificate
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

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

M 2.41 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-105909	Control Theory	6 CR	Schnaubelt

Competence Certificate
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

Recommendation
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.

M 2.42 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105831	Convex Geometry	8 CR	Hug

Competence Certificate
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.

2.43 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	English	4	1

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

Competence Certificate
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

Recommendation
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.

2.44 Module: Deep Learning and Neural Networks [M-INFO-104460]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-109124	Deep Learning and Neural Networks	6 CR	Niehues

M 2.45 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

Mandatory			
T-MATH-102275	Differential Geometry	8 CR	Tuschmann

Prerequisites
None

2.46 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	German	4	1

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

Competence Certificate
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

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

2.47 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

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

Competence Certificate
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

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

2.48 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-109001	Dispersive Equations	6 CR	Reichel

Competence Certificate
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

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

2.49 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-106114	Dynamical Systems	8 CR	Reichel

Competence Certificate
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

Recommendation
The module 'Functional Analysis' is recommended.

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

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	2

Mandatory			
T-ETIT-100640	Electromagnetics and Numerical Calculation of Fields	4 CR	Zwick

Competence Certificate
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

Recommendation

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 2.51 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 scale	Recurrence	Duration	Language	Level	Version
10	Grade to a tenth	Each winter term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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

Annotation
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)

Recommendation
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 2.52 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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

Annotation
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)

Recommendation
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

2.53 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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.

Annotation
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).

Recommendation
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

M 2.54 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

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

Competence Certificate
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 Conditions
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.

Annotation
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)

Recommendation
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

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

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113086	Ergodic Theory	8 CR	Link

Competence Certificate
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

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

M 2.56 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	German/English	4	1

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

Competence Certificate
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.

Annotation
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

Recommendation
The module “Functional Analysis” is strongly recommended.

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

M 2.57 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
Oral exam of approximately 20 minutes

Prerequisites
None

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.

M 2.58 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	2

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

Competence Certificate
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.

Annotation
Course is held in English

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

M 2.59 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	2

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

Competence Certificate
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

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

M 2.60 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

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

M 2.61 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	2 terms	English	4	2

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

Prerequisites
None

Annotation

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

M 2.62 Module: Formal Systems [M-INFO-100799]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101336	Formal Systems	6 CR	Beckert

2.63 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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Once	1 term	4	1

Mandatory			
T-MATH-107044	Foundations of Continuum Mechanics	3 CR	Wieners

Prerequisites
none

M 2.64 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	3

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

Prerequisites
None

2.65 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	2

Mandatory			
T-MATH-111296	Fractal Geometry	6 CR	Winter

Competence Certificate
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

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

M 2.66 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	2

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

Competence Certificate
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 2.67 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	2

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

Competence Certificate
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

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

M 2.68 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

M 2.69 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105905	Functions of Operators	6 CR	

Competence Certificate
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

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

M 2.70 Module: Fuzzy Sets [M-INFO-100839]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101376	Fuzzy Sets	6 CR	Hanebeck

M 2.71 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	2

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

Competence Certificate
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

Recommendation

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

2.72 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105892	Geometric Analysis	8 CR	Lamm

Prerequisites
none

M 2.73 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

M 2.74 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Prerequisites
none

M 2.75 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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.

Annotation
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

Recommendation
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.

M 2.76 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German/English	4	1

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

Competence Certificate
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

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

M 2.77 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

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

2.78 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Prerequisites
none

2.79 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-MATH-102273	Graph Theory	8 CR	Aksenovich

Competence Certificate
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.

Annotation

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

2.80 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

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

Prerequisites
none

2.81 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	2

Mandatory			
T-MATH-111289	Harmonic Analysis	8 CR	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

M 2.82 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

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

Competence Certificate
Oral examination of ca. 30 minutes.

Prerequisites
None

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

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

M 2.83 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	German	4	3

Mandatory			
T-CIWVT-106067	Heat Transfer II	4 CR	Wetzel

Competence Certificate
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): 30 h
- Homework: 50 h
- Exam Preparation: 40 h

Literature
Von Böckh/Wetzel: „Wärmeübertragung“, Springer, 6. Auflage 2015

VDI-Wärmeatlas, Springer-VDI, 10. Auflage, 2011

M 2.84 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

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

Competence Certificate
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 2.85 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-105933	Homotopy Theory	8 CR	Sauer

M 2.86 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

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

Prerequisites
None

M 2.87 Module: Information Security [M-INFO-106015]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-112195	Information Security	5 CR	Müller-Quade

2.88 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

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

Competence Certificate
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

2.89 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German/English	4	1

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

Competence Certificate
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.

Annotation
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

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

M 2.90 Module: Internship [M-MATH-102861]

Responsible: Prof. Dr. Willy Dörfler
PD Dr. Markus Neher

Organisation: KIT Department of Mathematics

Part of: Internship

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

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

Workload
Gesamter Arbeitsaufwand: 300 Stunden.

Präsenzzeit: 270 Stunden im Unternehmen.

Selbststudium: 30 Stunden

- Ausarbeitung des Berichtes
- Vorbereitung und Halten der Präsentation

M 2.91 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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Once	1 term	4	1

Mandatory			
T-MATH-105911	Introduction into Particulate Flows	3 CR	Dörfler

Prerequisites
none

M 2.92 Module: Introduction to Aperiodic Order [M-MATH-105331]

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

Credits	Grading scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-110811	Introduction to Aperiodic Order	3 CR	Hartnick

Prerequisites
None

M 2.93 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 scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-112194	Introduction to Artificial Intelligence	5 CR	Friederich, Neumann

Modeled Conditions
The following conditions have to be fulfilled:

1. The module M-INFO-100819 - Cognitive Systems must not have been started.

2.94 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112119	Introduction to Convex Integration	3 CR	Zillinger

Competence Certificate
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

Recommendation
The modules "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

M 2.95 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102384	Introduction to Cosmology	6 CR	Drexlin

Competence Certificate
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).

Recommendation
Basic knowledge from lecture "Nuclei and Particles

Literature
Will be mentioned in the lecture.

M 2.96 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113263	Introduction to Dynamical Systems	6 CR	de Rijk, Reichel

Competence Certificate
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

Recommendation
The following modules are strongly recommended: Analysis 1-2 and Linear Algebra 1-2. The module Analysis 4 is recommended.

M 2.97 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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	2

Mandatory			
T-MATH-111297	Introduction to Fluid Dynamics	3 CR	Reichel

Competence Certificate
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

Recommendation
The contents of the courses "Classical Methods for Partial Differential Equations" or "Boundary and Eigenvalue Problems" are recommended.

M 2.98 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112927	Introduction to Fluid Mechanics	6 CR	Liao

Competence Certificate
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

Recommendation
The module *Functional Analysis* is strongly recommended.

M 2.99 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105918	Introduction to Geometric Measure Theory	6 CR	Winter

Prerequisites
none

M 2.100 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-110323	Introduction to Homogeneous Dynamics	6 CR	Hartnick

Prerequisites
None

2.101 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-MATH-111721	Introduction to Kinetic Equations	3 CR	Zillinger

Competence Certificate
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

Recommendation
The contents of the course "Classical Methods for Partial Differential Equations" are recommended.

M 2.102 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-MATH-108013	Introduction to Kinetic Theory	4 CR	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

Recommendation
Partial Differential Equations, Functional Analysis

M 2.103 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111722	Introduction to Microlocal Analysis	3 CR	Liao

Competence Certificate
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

Recommendation
The following courses should be studied beforehand: "Classical Methods for Partial Differential Equations" und "Functional Analysis".

M 2.104 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	2

Mandatory			
T-MATH-105837	Introduction to Scientific Computing	8 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

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

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.

Annotation
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,
- literature study and internet research relating to the course content,
- preparation for the module examination

Recommendation

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 2.105 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112234	Introduction to Stochastic Differential Equations	4 CR	Janák, Trabs

Competence Certificate
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

Recommendation
The contents of the course "Probability Theory" are strongly recommended. The contents of the course "Continuous Time Finance" are recommended.

2.106 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

Mandatory			
T-MATH-105835	Inverse Problems	8 CR	Arens, Griesmaier, Hettlich, Rieder

Competence Certificate
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

Recommendation
The course "Functional Analysis" or "Integral Equations" is recommended as a prerequisite.

M 2.107 Module: IT Security [M-INFO-106315]

Responsible: Prof. Dr. Hannes Hartenstein
Prof. Dr. Jörn Müller-Quade
Prof. Dr. Thorsten Strufe
TT-Prof. Dr. Christian Wressnegger

Organisation: KIT Department of Informatics

Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German/English	4	2

Mandatory			
T-INFO-112818	IT Security	6 CR	Hartenstein, Müller-Quade, Strufe, Wressnegger

Competence Certificate
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
Based on the content of the compulsory lecture "Informationssicherheit ", this 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

Recommendation
Students should be familiar with the content of the compulsory lecture "Informationssicherheit".

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 2.108 Module: Key Competences [M-MATH-102994]

Organisation: KIT Department of Mathematics
Part of: Interdisciplinary Qualifications

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
2	pass/fail	Each term	1 term	German	4	3

Election notes

For self assignment of taken interdisciplinary qualifications of HoC, ZAK or SPZ the 'Teilleistungen' with the title "Self Assignment HoC-ZAK-SPZ ..." have to be selected according to the grading scale, not graded or graded.

Key Competences (Election: at least 2 credits)			
T-MATH-106119	Introduction to Python	3 CR	Weiß
T-MATH-111515	Self-Booking-HOC-SPZ-ZAK-1-Graded	2 CR	
T-MATH-111517	Self-Booking-HOC-SPZ-ZAK-2-Graded	2 CR	
T-MATH-111516	Self-Booking-HOC-SPZ-ZAK-5-Ungraded	2 CR	
T-MATH-111520	Self-Booking-HOC-SPZ-ZAK-6-Ungraded	2 CR	
T-MATH-111851	Introduction to Python - Programming Project	1 CR	Weiß

Prerequisites

None

M 2.109 Module: Key Moments in Geometry [M-MATH-104057]

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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-108401	Key Moments in Geometry	5 CR	Tuschmann

Prerequisites
None

M 2.110 Module: L2-Invariants [M-MATH-102952]

Responsible: Dr. Holger Kammeyer
Organisation: KIT Department of Mathematics
Part of: Applied Mathematics (Elective Field Applied Mathematics)
Mathematical Specialization (Elective Field Mathematical Specialization)
Additional Examinations

Credits	Grading scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105924	L2-Invariants	5 CR	Kammeyer, Sauer

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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-108799	Lie Groups and Lie Algebras	8 CR	Hartnick

M 2.112 Module: Lie-Algebras (Linear Algebra 3) [M-MATH-105839]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-111723	Lie-Algebras (Linear Algebra 3)	8 CR	

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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101377	Localization of Mobile Agents	6 CR	Hanebeck

M 2.114 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105921	Markov Decision Processes	5 CR	Bäuerle

Competence Certificate
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

Recommendation
The course 'Probability theory' is strongly recommended and 'Markov chains' is recommended.

M 2.115 Module: Master's Thesis [M-MATH-102917]

Responsible: PD Dr. Stefan Kühnlein
Organisation: KIT Department of Mathematics
Part of: Master's Thesis

Credits	Grading scale	Recurrence	Duration	Level	Version
30	Grade to a tenth	Each term	1 term	4	1

Mandatory			
T-MATH-105878	Master's Thesis	30 CR	Kühnlein

Competence Certificate
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 Conditions
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

M 2.116 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105862	Mathematical Methods in Signal and Image Processing	8 CR	Rieder

Competence Certificate
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

Recommendation
The course "Functional analysis" is recommended.

M 2.117 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-106488	Mathematical Methods of Imaging	5 CR	Rieder

Competence Certificate
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

Recommendation
The course „Functional Analysis“ is recommended.

2.118 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-MATH-105889	Mathematical Modelling and Simulation in Practise	4 CR	Thäter

Competence Certificate
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.

Annotation
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

Recommendation
Some basic knowledge of numerical mathematics is recommended.

Literature
Hans-Joachim Bungartz e.a.: Modeling and Simulation: An Application-Oriented Introduction, Springer, 2013

M 2.119 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	2

Mandatory			
T-MATH-105872	Mathematical Statistics	8 CR	Ebner, Fasen-Hartmann, Klar, Trabs

Competence Certificate
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

Recommendation
The contents of the courses "Probability theory" and "Statistics" are strongly recommended.

2.120 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-108403	Mathematical Topics in Kinetic Theory	4 CR	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

M 2.121 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105856	Maxwell's Equations	8 CR	Arens, Griesmaier, Hettlich

Competence Certificate
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

Recommendation
Desirable is basic knowledge from functional analysis

M 2.122 Module: Medical Imaging Technology I [M-ETIT-106449]

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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-113048	Medical Imaging Technology I	3 CR	Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 60 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
The module Medical Imaging Technology I provides knowledge on

- the basic knowledge of mathematical and physical principles of medical imaging formation, including X-ray based modalities, nuclear medicine imaging, magnetic resonance imaging and ultrasound
- the component 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.

Workload

1. attendance in lectures an exercises: 2SWS = 30 h
2. preparation / follow-up: 15*2 h = 30 h
3. preparation of and attendance in examination: 30 h

A total of 90 h = 3 CR

Recommendation
Basic knowledge in the field of physics and signal processing is helpful.

M 2.123 Module: Medical Imaging Technology II [M-ETIT-106670]

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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113421	Medical Imaging Technology II	3 CR	Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 60 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 student will be able to communicate in technical and clinical English language.

Content

- the basic knowledge of mathematical and physical principles of medical imaging formation, including nuclear medicine imaging and magnetic resonance imaging.
- the component 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.

Workload

- attendance in class: 15*2h = 30h
- preparation / follow-up: 15*2h = 30h
- exam preparation / attendance: 30h = 90h

A total of 90h = 3 CR

Recommendation

- Basic knowledge in the field of physics and signal processing is helpful.
- The contents of the module "Medical Imaging Technology I" are recommended.

2.124 Module: Methods of Signal Processing [M-ETIT-100540]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100694	Methods of Signal Processing	6 CR	Heizmann

Prerequisites
none

2.125 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-111933	Metric Geometry	8 CR	Lytchak, Nepechiy

Competence Certificate
oral examination of circa 20 minutes

Prerequisites
None

Module grade calculation
The module grade is the grade of the final oral exam.

2.126 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113417	Minimal Surfaces	3 CR	Lewintan

Competence Certificate
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

Recommendation
The course "Classical Methods for Partial Differential Equations" is recommended.

M 2.127 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113382	Modelling and Simulation of Lithium-Ion Batteries	4 CR	Dörfler

Competence Certificate
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

Recommendation
Basic knowledge in the numerical treatment of differential equations, such as boundary value problems or initial value problems is strongly recommended.

M 2.128 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105846	Models of Mathematical Physics	8 CR	Hundertmark, Plum, Reichel

Competence Certificate
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

M 2.129 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-PHYS-112846	Modern Experimental Physics I, Atoms, Nuclei and Molecules	8 CR	Studiendekan Physik

Competence Certificate
See components of this module

Prerequisites
none

M 2.130 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-PHYS-112847	Modern Experimental Physics II, Structure of Matter	8 CR	Studiendekan Physik

Competence Certificate
See components of this module

Prerequisites
none

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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105843	Modular Forms	8 CR	Kühnlein

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105877	Monotonicity Methods in Analysis	3 CR	Herzog

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Once	1 term	4	1

Mandatory			
T-MATH-105863	Multigrid and Domain Decomposition Methods	4 CR	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

2.134 Module: Neural Networks [M-INFO-100846]

Responsible: Prof. Dr. Alexander Waibel
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-101383	Neural Networks	6 CR	Waibel

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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-107065	Nonlinear Analysis	8 CR	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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-ETIT-100980	Nonlinear Control Systems	3 CR	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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-105848	Nonlinear Evolution Equations	8 CR	Frey, Schnaubelt

Competence Certificate
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

Recommendation
The contents of the modules Functional Analysis and Evolution Equations are strongly recommended. However, the relevant parts of Evolution Equations will be briefly recalled.

M 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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105876	Nonlinear Functional Analysis	3 CR	Herzog

Competence Certificate
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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-110283	Nonlinear Maxwell Equations	8 CR	Schnaubelt

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-110806	Nonlinear Wave Equations	4 CR	Reichel, Schnaubelt

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	2

Mandatory			
T-MATH-105873	Nonparametric Statistics	4 CR	Ebner, Fasen-Hartmann, Klar, Trabs

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	German	4	2

Mandatory			
T-MATH-111514	Numerical Analysis of Helmholtz Problems	3 CR	Verfürth

Competence Certificate
oral examination of circa 30 minutes

Prerequisites
none

Module grade calculation
The module grade is the grade of the final oral exam.

M 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113470	Numerical Analysis of Neural Networks	6 CR	Maier

Competence Certificate
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 in the context of partial differential equations (such as physics-informed neural networks).

Content

- Neural networks
- Approximation results
- Connections to finite element methods
- Numerical methods for the efficient learning
- Physics-informed neural networks

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

Recommendation
A solid background in numerical mathematics is strongly recommended. Basic knowledge of functional analysis and finite element methods is helpful, but not required.

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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-112280	Numerical Complex Analysis	6 CR	Hochbruck

Competence Certificate
oral exam of ca. 20 minutes

Prerequisites
none

Module grade calculation
The module grade ist the grade of the oral exam.

Workload
total workload: 180 h

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 scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-MATH-107497	Numerical Linear Algebra for Scientific High Performance Computing	5 CR	Anzt

Prerequisites
None

M 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-108402	Numerical Linear Algebra in Image Processing	6 CR	Grimm

Competence Certificate
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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

Mandatory			
T-MATH-105836	Numerical Methods for Differential Equations	8 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

Competence Certificate
The module will be completed by a written exam (120 min).

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 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

Recommendation
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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105900	Numerical Methods for Hyperbolic Equations	6 CR	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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105901	Numerical Methods for Integral Equations	8 CR	Arens, Hettlich

Competence Certificate
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 degenerate kernel approximation, 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
- Quadrature formulae
- Approximation by degenerate kernel functions
- Nyström methods
- Projection 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

Recommendation
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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105920	Numerical Methods for Maxwell's Equations	6 CR	Hochbruck, Jahnke

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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-113437	Numerical Methods for Oscillatory Differential Equations	8 CR	Jahnke

Competence Certificate
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.

Annotation
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

Recommendation

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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105899	Numerical Methods for Time-Dependent Partial Differential Equations	8 CR	Hochbruck, Jahnke

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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105860	Numerical Methods in Computational Electrodynamics	6 CR	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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-MATH-105902	Numerical Methods in Fluid Mechanics	4 CR	Dörfler, Thäter

Competence Certificate
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.

Recommendation
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.

M 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	German/English	4	1

Mandatory			
T-MATH-105865	Numerical Methods in Mathematical Finance	8 CR	Jahnke

Competence Certificate
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.

Annotation
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

Recommendation

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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105858	Numerical Optimisation Methods	8 CR	Dörfler, Hochbruck, Jahnke, Rieder, Wieners

M 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-110807	Numerical Simulation in Molecular Dynamics	8 CR	Grimm

Competence Certificate
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

Recommendation
The module M-MATH-102888 (Numerical Methods for Differential Equations) and some programming skills in C (or C++) are recommended.

M 2.158 Module: Optical Waveguides and Fibers [M-ETIT-100506]

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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-101945	Optical Waveguides and Fibers	4 CR	Koos

Competence Certificate
Type of Examination: Oral exam

Duration of Examination: approx. 20 minutes

Modality of Exam: The written exam is offered continuously upon individual appointment.

Prerequisites
None

Competence Goal
The students

- conceive the basic principles of light-matter-interaction and wave propagation in dielectric media and can explain the origin and the implications of the Lorentz model and of Kramers-Kronig relation,
- are able to quantitatively analyze the dispersive properties of optical media using Sellmeier relations and scientific databases,
- can explain and mathematically describe the working principle of an optical slab waveguide and the formation of guided modes,
- are able to program a mode solver for a slab waveguide in Matlab,
- are familiar with the basic principle of surface plasmon polariton propagation,
- know basic structures of planar integrated waveguides and are able to model special cases with semi-analytical approximations such as the Marcatili method or the effective-index method,
- are familiar with the basic concepts of numerical mode solvers and the associated limitations,
- are familiar with state-of-the-art waveguide technologies in integrated optics and the associated fabrication methods,
- know basic concepts of of step-index fibers, graded-index fibers and microstructured fibers,
- are able to derive and solve basic relations for step-index fibers from Maxwell's equations,
- are familiar with the concept of hybrid and linearly polarized fiber modes,
- can mathematically describe signal propagation in single-mode fibers design dispersion-compensated transmission links,
- conceive the physical origin of fiber attenuation effects,
- are familiar with state-of-the-art fiber technologies and the associated fabrication methods,
- can derive models for dielectric waveguide structures using the mode expansion method,
- conceive the principles of directional couplers, multi-mode interference couplers, and waveguide gratings,
- can mathematically describe active waveguides and waveguide bends.

Content

1. Introduction: Optical communications
2. Fundamentals of wave propagation in optics: Maxwell´s equations in optical media, wave equation and plane waves, material dispersion, Kramers-Kroig relation and Sellmeier equations, Lorentz and Drude model of refractive index, signal propagation in dispersive media.
3. Slab waveguides: Reflection from a plane dielectric boundary, slab waveguide eigenmodes, radiation modes, inter- and intramodal dispersion, metal-dielectric structures and surface plasmon polariton propagation.
4. Planar integrated waveguides: Basic structures of integrated optical waveguides, guided modes of rectangular waveguides (Marcatili method and effective-index method), basics of numerical methods for mode calculations (finite difference- and finite-element methods), waveguide technologies in integrated optics and associated fabrication methods
5. Optical fibers: Optical fiber basics, step-index fibers (hybrid modes and LP-modes), graded-index fibers (infinitely extended parabolic profile), microstructured fibers and photonic-crystal fibers, fiber technologies and fabrication methods, signal propagation in single-mode fibers, fiber attenuation, dispersion and dispersion compensation
6. Waveguide-based devices: Modeling of dielectric waveguide structures using mode expansion and orthogonality relatons, multimode interference couplers and directional couplers, waveguide gratings, material gain and absorption in optical waveguides, bent waveguides

Module grade calculation
The module grade is the grade of the oral exam.

There is, however, a bonus system based on the problem sets that are solved during the tutorials: During the term, 3 problem sets will be collected in the tutorial and graded without prior announcement. If for each of these sets more than 70% of the problems have been solved correctly, a bonus of 0.3 grades will be granted on the final mark of the oral exam.

Workload
Total 120 h, hereof 45 h contact hours (30 h lecture, 15 h tutorial) and 75 h homework and self-studies.

Recommendation
Solid mathematical and physical background, basic knowledge of electrodynamics

Literature
B.E.A. Saleh, M.C. Teich: Fundamentals of Photonics

G.P. Agrawal: Fiber-optic communication systems

C.-L. Chen: Foundations for guided-wave optics

Katsunari Okamoto: Fundamentals of Optical Waveguides

K. Iizuka: Elements of Photonics

2.159 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German	1	1

Mandatory			
T-ETIT-104594	Optimal Control and Estimation	3 CR	Hohmann

Prerequisites
none

M 2.160 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105864	Optimisation and Optimal Control for Differential Equations	4 CR	

Prerequisites
none

M 2.161 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	2

Mandatory			
T-MATH-105893	Optimization in Banach Spaces	5 CR	Griesmaier, Hettlich

Competence Certificate
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

Recommendation
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.

M 2.162 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 scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-ETIT-100685	Optimization of Dynamic Systems	5 CR	Hohmann

Competence Certificate
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.

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)

M 2.163 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-102271	Parallel Computing	5 CR	Krause, Wieners

Prerequisites
None

M 2.164 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-PHYS-102369	Particle Physics I	8 CR	Ferber, Husemann, Klute, Quast, Rabbertz

Competence Certificate
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.

Annotation
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)

Recommendation
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 2.165 Module: Pattern Recognition [M-INFO-100825]

Responsible: Prof. Dr.-Ing. Jürgen Beyerer
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	2

Mandatory			
T-INFO-101362	Pattern Recognition	6 CR	Beyerer, Zander

M 2.166 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	2

Mandatory			
T-MATH-105869	Percolation	5 CR	Hug, Last, Winter

Competence Certificate
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

Recommendation
The contents of the module *Probability Theory* are recommended.

M 2.167 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-CIWVT-106103	Physical Foundations of Cryogenics	6 CR	Grohmann

Competence Certificate
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 2.168 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 scale	Recurrence	Duration	Level	Version
5	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105922	Poisson Processes	5 CR	Fasen-Hartmann, Hug, Last, Nestmann, Winter

Competence Certificate
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

Recommendation
The contents of the module *Probability Theory* are recommended.

M 2.169 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105850	Potential Theory	8 CR	Arens, Griesmaier, Hettlich, Reichel

Competence Certificate
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 2.170 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105923	Probability Theory and Combinatorial Optimization	8 CR	Hug, Last

Competence Certificate
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.

Recommendation

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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-CIWVT-106101	Process Modeling in Downstream Processing	4 CR	Franzreb

Competence Certificate
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

M 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106107	Processing of Nanostructured Particles	6 CR	Nirschl

Competence Certificate
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

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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-112241	Random Graphs and Networks	8 CR	Hug

Competence Certificate
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.

Annotation
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.

Recommendation

The contents of the module 'Probability Theory' are strongly recommended.

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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-INFO-101340	Real-Time Systems	6 CR	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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113472	Regularity for Elliptic Operators	6 CR	Kunstmann

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-113081	Riemann Surfaces	8 CR	Herrlich

Competence Certificate
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

Recommendation
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-100893]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German/English	4	3

Mandatory			
T-INFO-108014	Robotics I - Introduction to Robotics	6 CR	Asfour

Competence Certificate
See partial achivements (Teilleistung)

Prerequisites
See partial achivements (Teilleistung)

Competence Goal
The student is 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 student masters the kinematic and dynamic modeling of robot systems, as well as the modeling and design of simple controllers. The student knows the algorithmic basics of motion and grasp planning and can apply these algorithms to problems in robotics. He/she knows algorithms from the field of image processing and is able to apply them to problems in robotics. He/she is able to model and solve tasks as a symbolic planning problem. The student has knowledge about intuitive programming procedures for robots and knows 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

M 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	3

Mandatory			
T-INFO-105723	Robotics II - Humanoid Robotics	3 CR	Asfour

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-INFO-109931	Robotics III - Sensors and Perception in Robotics	3 CR	Asfour

Competence Certificate
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

Recommendation
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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-108400	Ruin Theory	4 CR	Fasen-Hartmann

Competence Certificate
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

Recommendation
The content of the module "Probability Theory" is recommended.

M 2.181 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105855	Scattering Theory	8 CR	Arens, Griesmaier, Hettlich

Competence Certificate
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

Recommendation
One of the following modules should already be covered: functional analysis or integral equations

2.182 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	German/English	4	1

Mandatory			
T-MATH-113416	Scattering Theory for Time-dependent Waves	6 CR	Griesmaier

Competence Certificate
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

Recommendation
The modules *Functional Analysis* and/or *Integral Equations* are recommended.

M 2.183 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111853	Selected Methods in Fluids and Kinetic Equations	3 CR	

Competence Certificate
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

Recommendation
The modules "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

2.184 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 scale	Recurrence	Duration	Level	Version
3	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-109065	Selected Topics in Harmonic Analysis	3 CR	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

2.185 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-113415	Semigroup Theory for the Navier-Stokes Equations	6 CR	Tolksdorf

Competence Certificate
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

Recommendation
The following modules are strongly recommended: *Functional Analysis* and *Classical Methods for Partial Differential Equations.*

2.186 Module: Seminar [M-MATH-102730]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	pass/fail	Each term	1 term	German/English	4	3

Elective Seminar (Election: 1 item)			
T-MATH-105686	Seminar Mathematics	3 CR	Kühnlein

Competence Certificate
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

2.187 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 scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Each summer term	1 term	German/English	4	1

Mandatory			
T-INFO-103584	Seminar Advanced Topics in Parallel Programming	3 CR	Streit

M 2.188 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-ETIT-113428	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	6 CR	Wahls

Competence Certificate
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.

Annotation

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

Recommendation

Familiarity with signals and systems at the Bachelor level (Fourier and Laplace transforms, linear systems, etc.) is assumed.

M 2.189 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German/English	4	2

Mandatory			
T-MATH-105896	Sobolev Spaces	8 CR	Schnaubelt

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

Prerequisites
None

Competence Goal
Students can explain the significance of Sobolev spaces in the theory of partial differential equations.They are able to reproduce and prove the most important properties.

Content
Definition of Sobolev spaces for functions on Lipschitz domains, density, continuation and trace theorems, compact embeddings, Helmholtz decomposition, 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

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

M 2.190 Module: Software Engineering II [M-INFO-100833]

Responsible: Prof. Dr.-Ing. Anne Koziolek
Prof. Dr. Ralf Reussner

Organisation: KIT Department of Informatics

Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101370	Software Engineering II	6 CR	Koziolek, Reussner

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

2.191 Module: Space and Time Discretization of Nonlinear Wave Equations [M-MATH-105966]

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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-112120	Space and Time Discretization of Nonlinear Wave Equations	6 CR	Hochbruck

M 2.192 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each winter term	1 term	4	1

Mandatory			
T-MATH-105867	Spatial Stochastics	8 CR	Hug, Last, Winter

Competence Certificate
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

Recommendation
The contents of the module *Probability Theory* are recommended.

M 2.193 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	see Annotations	1 term	English	4	1

Mandatory			
T-MATH-105891	Special Topics of Numerical Linear Algebra	8 CR	Grimm, Hochbruck, Neher

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

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.

Annotation
Bi-yearly course.

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

Recommendation
Numerical analysis 1 and 2

M 2.194 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-MATH-103414	Spectral Theory - Exam	8 CR	Frey, Herzog, Kunstmann, Schnaubelt, Tolksdorf

Competence Certificate
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

Recommendation
The module „Functional Analysis“ is strongly recommended.

M 2.195 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105851	Spectral Theory of Differential Operators	8 CR	Plum

2.196 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-110805	Splitting Methods for Evolution Equations	6 CR	Jahnke

Competence Certificate
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.

Annotation
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

Recommendation
Familiarity with ordinary differential equations, Runge-Kutta methods (construction, order, stability) and Sobolev spaces (definition, basic properties, Sobolev embeddings) is strongly recommended.

M 2.197 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

Mandatory			
T-MATH-111726	Statistical Learning	8 CR	Trabs

Competence Certificate
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

Recommendation
The modules "Probability Theory" and "Statistics" (M-MATH-103220) are recommended.

M 2.198 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	German	4	3

Mandatory			
T-CIWVT-106098	Statistical Thermodynamics	6 CR	Enders

Competence Certificate
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
Thermodynamics III

Modeled Conditions
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.

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.

M 2.199 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-111187	Steins Method with Applications in Statistics	4 CR	Ebner, Hug

Prerequisites
None

2.200 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105871	Stochastic Control	4 CR	Bäuerle

Competence Certificate
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

Recommendation
The course 'Probably Theory' is strongly recommended. The courses 'Brownian motion' and 'Continuous time finance' are recommended.

M 2.201 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105852	Stochastic Differential Equations	8 CR	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

2.202 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Each summer term	1 term	4	1

Mandatory			
T-MATH-105840	Stochastic Geometry	8 CR	Hug, Last, Winter

Competence Certificate
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.

Recommendation
It is recommended to have taken the module 'Spatial Stochastics' beforehand.

2.203 Module: Stochastic Information Processing [M-INFO-100829]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-INFO-101366	Stochastic Information Processing	6 CR	Hanebeck

M 2.204 Module: Stochastic Simulation [M-MATH-106053]

Responsible: TT-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 scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	English	4	1

Mandatory			
T-MATH-112242	Stochastic Simulation	5 CR	Krumscheid

Competence Certificate
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

Recommendation
The contents of the modules 'M-MATH-101321 - Introduction to Stochastics' and 'M-MATH-103214 – Numerical Mathematics 1+2' are recommended.

2.205 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-MATH-111004	Structural Graph Theory	4 CR	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.

Recommendation
A solid background in the fundamentals of graph theory.

M 2.206 Module: Supplementary Studies on Culture and Society [M-ZAK-106235]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
22	Grade to a tenth	Each term	3 terms	German	4	1

Election notes
With the exception of the final oral exam and the practice module, students have to self-record the achievements obtained in the Supplementary Studies on Culture and Society in their study plan. 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 ZAK homepage at https://www.zak.kit.edu/begleitstudium-bak.php. The title of the examination and the amount of credits override the modules placeholders.

If you want to use ZAK achievements **both for your interdisciplinary qualifications and for the supplementary studies**, please record them in the interdisciplinary qualifications first. You can then get in contact with the ZAK study services (stg@zak.kit.edu) to also record them in your supplementary studies.

In the in-depth module, achievements have to be obtained in three different areas. The areas are as follows:

- Technology & Responsibility
- Doing Culture
- Media & Aesthetics
- Spheres of Life
- Global Cultures

You have to obtain two achievements with 3 credits each and one achievement with 5 credits. To self-record achievements in the in-depth module, you first have to elect the matching partial achievement.

Note: If you registered for the Supplementary Studies on Sustainable Development before April 1st, 2023, self-recording an achievement in this module counts as a request in the sense of §20 (2) of the regulations for the Supplementary Studies on Culture and Society. Your overall grade for the supplementary studies will thus be calculated as the average of the examantion grades, not as the average of the module grades.

Mandatory			
T-ZAK-112653	Basics Module - Self Assignment BAK	3 CR	Mielke, Myglas
In-depth Module (Election: 3 items)			
T-ZAK-112654	In-depth Module - Technology & Responsibility - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112655	In-depth Module - Doing Culture - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112656	In-depth Module - Media & Aesthetics - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112657	In-depth Module - Spheres of Life - Self Assignment BAK	3 CR	Mielke, Myglas
T-ZAK-112658	In-depth Module - Global Cultures - Self Assignment BAK	3 CR	Mielke, Myglas
Mandatory			
T-ZAK-112660	Practice Module	4 CR	Mielke, Myglas
T-ZAK-112659	Oral Exam - Supplementary Studies on Culture and Society	4 CR	Mielke, Myglas

Competence Certificate
The monitoring is explained in the respective partial achievement.

They are composed of:

- minutes
- presentations
- a seminar paper
- an internship report
- an oral examination

After successful completion of the supplementary studies, the graduates receive a graded certificate and a KIT certificate.

Prerequisites

The offer is study-accompanying and does not have to be completed within a defined period of time. Enrolment or acceptance for graduation must be present when registering for the final examination.

KIT students register for the supplementary studies by selecting this module in the student portal and self-checking a performance. In addition, registration for the individual courses is necessary, which is possible shortly before the beginning of each semester.

The course catalogue, statutes (study regulations), registration form for the oral exam, and guides for preparing the various written performance requirements can be found as downloads on the ZAK homepage at www.zak.kit.edu/begleitstudium-bak.

Competence Goal

Graduates of the Supplementary Studies on Culture and Society demonstrate a sound basic knowledge of conditions, procedures and concepts for analysing and shaping fundamental social development tasks in connection with cultural topics. They have gained a well-founded theoretical and practical insight into various cultural studies and interdisciplinary topics in the field of tension between culture, technology and society in the sense of an expanded concept of culture.

They are able to place the contents selected from the specialization module in the basic context as well as to analyse and evaluate the contents of the selected courses independently and exemplarily and to communicate about them scientifically in written and oral form. Graduates are able to analyse social topics and problem areas and critically reflect on them in a socially responsible and sustainable perspective.

Content

The Supplementary Studies on Culture and Society can be started from the 1st semester and is not limited in time. It comprises at least 3 semesters. The supplementary studies are divided into 3 modules (basics, in-depth studies, practice). A total of 22 credit points (ECTS) are earned.

The thematic elective areas of the supplementary studies are divided into the following 5 modules and their sub-topics:

Block 1Technology & Responsibility

Value change / ethics of responsibility, technology development / history of technology, general ecology, sustainability

Block 2Doing Culture

Cultural studies, cultural management, creative industries, cultural institutions, cultural policy

Block 3Media & Aesthetics

Media communication, cultural aesthetics

Block 4Spheres of Life

Cultural sociology, cultural heritage, architecture and urban planning, industrial science

Block 5Global Cultures

Multiculturalism / interculturalism / transculturalism, science and culture

Module grade calculation

The overall grade of the supplementary studies is calculated as an average of the grades of the examination performances weighted with credit points.

In-depth Module

- presentation 1 (3 ECTS)
- presentation 2 (3 ECTS)
- seminar paper incl. presentation (5 ECTS)
- oral examination (4 ECTS)

Annotation
With the Supplementary Studies on Culture and Society, KIT provides a multidisciplinary study offer as an additional qualification, with which the respective specialized study program is supplemented by interdisciplinary basic knowledge and interdisciplinary orientation knowledge in the field of cultural studies, which is becoming increasingly important for all professions.

Within the framework of the supplementary studies, students acquire in-depth knowledge of various cultural studies and interdisciplinary subject areas in the field of tension between culture, technology and society. In addition to high culture in the classical sense, other cultural practices, common values and norms as well as historical perspectives of cultural developments and influences are considered.

In the courses, conditions, procedures and concepts for the analysis and design of fundamental social development tasks are acquired on the basis of an expanded concept of culture. This includes everything created by humans - also opinions, ideas, religious or other beliefs. The aim is to develop a modern concept of cultural diversity. This includes the cultural dimension of education, science and communication as well as the preservation of cultural heritage. (UNESCO, 1982)

According to § 16 of the statutes, a reference and a certificate are issued by the ZAK for the supplementary studies. The achievements are also shown in the transcript of records of the degree program and, upon request, in the certificate. They can also be recognized in the interdisciplinary qualifications (see elective information).

Workload
The workload is made up of the recommended number of hours for the individual modules:

- basic module approx. 90 h
- in-depth module approx. 340 h
- practical module approx. 120 h

total: approx. 550 h

Learning type

- lectures
- seminars
- workshops
- practical course

Literature
Recommended reading of primary and specialized literature will be determined individually by each instructor.

2.207 Module: Supplementary Studies on Sustainable Development [M-ZAK-106099]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: Additional Examinations

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
19	Grade to a tenth	Each term	3 terms	German	4	1

Election notes

With the exception of the final oral exam, students have to self-record the achievements obtained in the Supplementary Studies on Sustainable Development in their study plan. 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 ZAK homepage at https://www.zak.kit.edu/begleitstudium-bene. The title of the examination and the amount of credits override the modules placeholders.

If you want to use ZAK achievements **both for your interdisciplinary qualifications and for the supplementary studies**, please record them in the interdisciplinary qualifications first. You can then get in contact with the ZAK study services (stg@zak.kit.edu) to also record them in your supplementary studies.

In the elective module, you need to obtain 6 credits worth of achievements in two of the four areas:

- Sustainable Cities & Neighbourhoods
- Sustainable Assessment of Technology
- Subject, Body, Individual: The Other Side of Sustainability
- Sustainability in Culture, Economy & Society

Usually, two achievements with 3 credits each have to be obtained. To self-record achievements in the elective module, you first have to elect the matching partial achievement.

Note: If you registered for the Supplementary Studies on Sustainable Development before April 1st, 2023, self-recording an achievement in this module counts as a request in the sense of §19 (2) of the regulations for the Supplementary Studies on Sustainable Development. Your overall grade for the supplementary studies will thus be calculated as the average of the examantion grades, not as the average of the module grades.

Mandatory			
T-ZAK-112345	Basics Module - Self Assignment BeNe	3 CR	Myglas
Elective Module (Election: at least 6 credits)			
T-ZAK-112347	Elective Module - Sustainable Cities and Neighbourhoods - Self Assignment BeNe	3 CR	
T-ZAK-112348	Elective Module - Sustainability Assessment of Technology - Self Assignment BeNe	3 CR	
T-ZAK-112349	Elective Module - Subject, Body, Individual: the Other Side of Sustainability - Self Assignment BeNe	3 CR	
T-ZAK-112350	Elective Module - Sustainability in Culture, Economy and Society - Self Assignment BeNe	3 CR	
Mandatory			
T-ZAK-112346	Specialisation Module - Self Assignment BeNe	6 CR	Myglas
T-ZAK-112351	Oral Exam - Supplementary Studies on Sustainable Development	4 CR	

Competence Certificate
The monitoring is explained in the respective partial achievement .

They are composed of:

- protocols
- a reflection report
- presentations
- presentations
- the elaboration of a project work
- an individual term paper

Upon successful completion of the supplementary studies, graduates receive a graded report and a certificate issued by ZAK.

Prerequisites
The course is offered during the course of study and does not have to be completed within a defined period of time. Enrolment is required for all performance assessments of the modules of 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 self-booking a performance. Registration for courses, performance assessments and examinations is regulated by § 6 of the Statutes and is usually possible shortly before the beginning of the semester.

The course catalogue, statutes (study regulations), registration form for the oral exam and guidelines for preparing the various written performance requirements can be found as downloads on the ZAK homepage at http://www.zak.kit.edu/begleitstudium-bene.

Competence Goal
Graduates of the supplementary studies in sustainable development acquire additional practical and professional competencies. Thus, the supplementary study program enables the acquisition of basics and initial experience in project management, trains teamwork skills, presentation skills and self-reflection, and also creates a fundamental understanding of sustainability that is relevant for all professional fields.

Graduates are able to analyse social topics and problem areas and critically reflect on them in a socially responsible and sustainable perspective. They are able to place the contents selected from the modules "Elective" and "Advanced" in the basic context as well as to independently and exemplarily analyse and evaluate the contents of the selected courses and to scientifically communicate about them in written and oral form.

Content
The supplementary study program Sustainable Development can be started from the 1st semester and is not limited in time. The wide range of courses offered by ZAK makes it possible to complete the program usually within three semesters. The supplementary studies comprise 19 credit points (LP). It consists of three modules: Basic Module, Elective Module and Advanced Module.

The thematic elective areas of the supplementary studies are divided into the following 4 modules and their subtopics in Module 2 (elective module):

Block 1 **Sustainable Cities and Neighbourhoods**

The courses provide an overview of the interaction of social, ecological, and economic dynamics in the microcosm of the city.

Block 2 **Sustainability Assessment of Technology**

Mostly based on ongoing research activities, methods and approaches of technology assessment are elaborated.

Block 3 **Subject, Body, Individual: The other Side of Sustainability**

Different approaches are presented to the individual perception, experience, shaping and responsibility of relationships to the environment and to oneself.

Block 4 **Sustainability in Culture, Economy & Society**

Courses usually have an interdisciplinary approach, but may also focus on one of the areas of culture, economics or society, both in application and in theory.

The core of the supplementary studies is a case study in the specialization area. In this project seminar, students conduct sustainability research with practical relevance themselves. The case study is supplemented by an oral examination with two topics from module 2 (elective module) and module 3 (in-depth module).

Module grade calculation

The overall grade of the supplementary studies is calculated as an average of the grades of the examination performances weighted with credit points.

Elective module

- Presentation 1 (3 ECTS)

- Presentation 2 (3 ECTS)

Advanced module

- individual term paper (6 ECTS)

- oral examination (4 ECTS)

Annotation

The Supplementary Studies on Sustainable Development at KIT is based on the conviction that a long-term socially and ecologically compatible coexistence in the global world is only possible if knowledge about necessary changes in science, economy and society is acquired and applied.

The interdisciplinary and transdisciplinary Studies on Sustainable Development enables diverse access to transformation knowledge as well as basic principles and application areas of sustainable development. According to the statutes § 16, a certificate is issued by the ZAK for the complementary studies.

The achievements are also shown in the transcript of records of the degree program and, upon request, in the certificate. They can also be recognized in the interdisciplinary qualifications (see elective information).
In the specialised studies, modules and partial achievements can be recognised within the framework of the additional achievements or e.g. the interdisciplinary qualifications. This must be regulated via the respective subject study programme.

The focus is on experience- and application-oriented knowledge and competences, but theories and methods are also learned. The aim is to be able to represent one's own actions as a student, researcher and later decision-maker as well as an individual and part of society under the aspect of sustainability.

Sustainability is understood as a guiding principle to which economic, scientific, social and individual actions should be oriented. According to this, the long-term and socially just use of natural resources and the material environment for a positive development of global society can only be addressed by means of integrative concepts. Therefore, "education for sustainable development" in the sense of the United Nations programme plays just as central a role as the goal of promoting "cultures of sustainability". For this purpose, practice-centred and research-based learning of sustainability is made possible and the broad concept of culture established at ZAK is used, which understands culture as habitual behaviour, lifestyle and changing context for social actions.

The supplementary study programme conveys the basics of project management, trains teamwork skills, presentation skills and self-reflection. Complementary to the specialised studies at KIT, it creates a fundamental understanding of sustainability, which is important for all professional fields. Integrative concepts and methods are essential: in order to use natural resources in the long term and to shape the global future in a socially just way, not only different disciplines, but also citizens, practitioners and institutions must work together.

Workload

The workload is made up of the number of hours of the individual modules:

- Basic module approx. 180 h
- Elective module approx. 150 h
- Consolidation module approx. 180 h

Total: approx. 510 h

Learning type

- lectures
- seminars
- workshops

Literature

Recommended reading of primary and specialist literature is determined individually by the respective lecturer.

2.208 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 scale	Recurrence	Duration	Language	Level	Version
5	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-ETIT-100804	Technical Optics	5 CR	Neumann

Prerequisites
none

M 2.209 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 scale	Recurrence	Duration	Level	Version
3	pass/fail	Each term	1 term	4	1

Mandatory			
T-MATH-105884	Technomathematical Seminar	3 CR	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.

2.210 Module: Telematics [M-INFO-100801]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: Computer Science

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German/English	4	1

Mandatory			
T-INFO-101338	Telematics	6 CR	Zitterbart

Competence Certificate
See partial achievement.

Prerequisites
See partial achievement.

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
180 hrs.

2.211 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	1

Mandatory			
T-PHYS-104587	Theoretical Nanooptics	6 CR	Garst, Rockstuhl

Competence Certificate
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)

Recommendation
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 2.212 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each summer term	1 term	English	4	1

Mandatory			
T-PHYS-104578	Theoretical Optics	6 CR	Narozhnyy, Rockstuhl

Competence Certificate
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)

Annotation
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)

Recommendation
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

M 2.213 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Each winter term	1 term	German	4	1

Mandatory			
T-CIWVT-106033	Thermodynamics III	6 CR	Enders

Competence Certificate
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 2.214 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 scale	Recurrence	Duration	Language	Level	Version
4	Grade to a tenth	Each summer term	1 term	German	4	1

Mandatory			
T-CIWVT-106100	Thermodynamics of Interfaces	4 CR	Enders

Competence Certificate
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.

M 2.215 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Each summer term	1 term	4	2

Mandatory			
T-MATH-105874	Time Series Analysis	4 CR	Ebner, Fasen-Hartmann, Gneiting, Klar, Trabs

Competence Certificate
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

Recommendation
The contents of the course "Probability Theory" are strongly recommended. The contents of the course "Statistics" are recommended.

M 2.216 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 scale	Recurrence	Duration	Level	Version
6	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-111031	Topological Data Analysis	6 CR	Hartnick, Sauer

M 2.217 Module: Topological Genomics [M-MATH-106064]

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

Credits	Grading scale	Recurrence	Duration	Language	Level	Version
3	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-112281	Topological Genomics	3 CR	Ott

Competence Certificate
oral exam of ca. 20 min

Prerequisites
None

Module grade calculation
The grade of the module is the grade of the oral exam.

Workload
total workload: 90 hours

M 2.218 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 scale	Recurrence	Duration	Language	Level	Version
8	Grade to a tenth	Irregular	1 term	German	4	1

Mandatory			
T-MATH-112128	Translation Surfaces	8 CR	Herrlich

Competence Certificate
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

Recommendation
Basic knowledge in surface topology and complex analysis is strongly recommended. The module "Algebraic Geometry" is also recommended.

M 2.219 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 scale	Recurrence	Duration	Language	Level	Version
6	Grade to a tenth	Irregular	1 term	English	4	2

Mandatory			
T-MATH-105897	Traveling Waves	6 CR	de Rijk, Reichel

Competence Certificate
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

Recommendation
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 2.220 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 scale	Recurrence	Duration	Level	Version
4	Grade to a tenth	Each summer term	1 term	4	1

Mandatory			
T-MATH-108399	Uncertainty Quantification	4 CR	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.

Recommendation
Numerical methods for differential equations

2.221 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-110302	Variational Methods	8 CR	Reichel

Competence Certificate
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

Recommendation
The contents of the courses Functional Analysis, Classical Methods for Partial Differential Equations, or Boundary and Eigenvalue problems are recommended.

M 2.222 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 scale	Recurrence	Duration	Level	Version
8	Grade to a tenth	Irregular	1 term	4	1

Mandatory			
T-MATH-105838	Wavelets	8 CR	Rieder

Competence Certificate
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

Recommendation
The course "Functional analysis" is recommended.

3 Courses

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 scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2024	0160610	Tutorial for 0160600 (Numerical Methods in Fluidmechanics)	1 SWS	Practice	Dörfler

Prerequisites
none

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 scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

T 3.3 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 scale	Version
Oral examination	8	Grade to a third	2

Events					
WT 23/24	0102200	Algebra	4 SWS	Lecture / 🗣	Sauer
WT 23/24	0102210	Tutorial for 0102200 (Algebra)	2 SWS	Practice / 🗣	Sauer
Exams					
WT 23/24	7700136	Algebra			Sauer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.4 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0152000	Algebraische Geometrie	4 SWS	Lecture	Herrlich
ST 2024	0152010	Übungen zu 0152000 (Algebraische Geometrie)	2 SWS	Practice	Herrlich

T 3.5 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 scale	Version
Oral examination	8	Grade to a third	1

Exams			
WT 23/24	7700099	Algebraic Number Theory	Herrlich

Competence Certificate
oral examination of ca. 30 minutes

Prerequisites
none

T 3.6 Course: Algebraic Topology [T-MATH-105915]

Responsible: TT-Prof. Dr. Manuel Krannich
Prof. Dr. Roman Sauer

Organisation: KIT Department of Mathematics

Part of: M-MATH-102948 - Algebraic Topology

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 3.7 Course: Algebraic Topology II [T-MATH-105926]

Responsible: Prof. Dr. Roman Sauer
Organisation: KIT Department of Mathematics
Part of: M-MATH-102953 - Algebraic Topology II

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 3.8 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Events					
WT 23/24	0100046	Analytical and numerical homogenization	3 SWS	Lecture	Maier
Exams					
WT 23/24	7700139	Analytical and Numerical Homogenization			Maier

Prerequisites
none

T 3.9 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 3.10 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
ST 2024	0176600	AG Geometrische Analysis	2 SWS	Seminar	Lamm

Prerequisites
Keine

3.11 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4022011	Astroparticle Physics I: Dark Matter	3 SWS	Lecture / 🗣	Drexlin, Valerius, Lokhov
WT 23/24	4022012	Exercises to Astroparticle Physics I: Dark Matter	1 SWS	Practice / 🗣	Drexlin, Valerius, Huber

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
none

T 3.12 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 scale	Version
Oral examination	3	Grade to a third	1

Prerequisites
none

T 3.13 Course: Basics Module - Self Assignment BAK [T-ZAK-112653]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Completed coursework	3	pass/fail	1

Competence Certificate

The monitoring in this module includes a course credit according to § 5 section 4 in the form of minutes of which two are to be handed in freely chosen topics of the lecture series " Introduction to Applied Studies on Culture and Society ". Length: approx. 6,000 characters each (incl. spaces).

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation

Fjordevik, Anneli und Jörg Roche: Angewandte Kulturwissenschaften. Vol. 10. Narr Francke Attempto Verlag, 2019.

Annotation

The Basic Module consists of the lecture “Introduction to Supplementary Studies on Culture and Society”, which is offered only in the winter semester. It is therefore recommended that students start their studies in the winter semester and complete them before module 2.

T 3.14 Course: Basics Module - Self Assignment BeNe [T-ZAK-112345]

Responsible: Christine Myglas
Organisation:
Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Completed coursework	3	pass/fail	1

Competence Certificate
The monitoring in this module includes a course credit according to § 5 section 4:

Introduction to Sustainable Development in the form of minutes of which two are to be handed in freely chosen topics of the lecture series "Introduction to Sustainable Development". Length: approx. 6,000 characters each (incl. spaces).

or

Sustainability Spring Days at KIT in the form of a reflection report on all components of the project days "Sustainability Spring Days at KIT". Length approx. 12,000 characters (incl. spaces).

Prerequisites
None

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation
Kropp, Ariane: Grundlagen der Nachhaltigen Entwicklung: Handlungsmöglichkeiten und Strategien zur Umsetzung. Springer-Verlag, 2018.

Pufé, Iris: Nachhaltigkeit. 3. überarb. Edition, UTB, 2017.

Roorda, Niko, et al.: Grundlagen der nachhaltigen Entwicklung. Springer-Verlag, 2021.

Annotation
Module Basics consists of the lecture " Introduction to Sustainable Development ", which is only offered in the summer semester or alternatively of the project days " Sustainability Spring Days at KIT ", which is only offered in the winter semester. It is recommended to complete the course before Elective Module an Specialisation Module.

In exceptional cases, Elective Module or Specialisation Module can also be completed simultaneously with Basics Module. However, the prior completion of the advanced modules Elective and Specialisation should be avoided.

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 scale	Version
Oral examination	4	Grade to a third	1

Events					
WT 23/24	4021041	Nanotechnology I	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 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 scale	Version
Oral examination	4	Grade to a third	1

Events					
ST 2024	4021151	Basics of Nanotechnology II	2 SWS	Lecture / 🗣	Goll

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.17 Course: Batteries and Fuel Cells [T-ETIT-100983]

Responsible: Prof. Dr.-Ing. Ulrike Krewer
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100532 - Batteries and Fuel Cells

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	3

Events					
WT 23/24	2304207	Batteries and Fuel Cells	2 SWS	Lecture / Blended	Krewer
WT 23/24	2304213	Batteries and Fuel Cells (Exercise to 2304207)	1 SWS	Practice / On-Site	Krewer, Lindner
Exams					
WT 23/24	7304207	Batteries and Fuel Cells			Krewer
ST 2024	7300006	Batteries and Fuel Cells			Krewer

Legend: Online, Blended (On-Site/Online), On-Site, × Cancelled

Prerequisites
none

Below you will find excerpts from events related to this course:

V Batteries and Fuel Cells

2304207, WS 23/24, 2 SWS, Language: German, Open in study portal

Lecture (V)
Blended (On-Site/Online)

Content
The lecture provides a practical insight into the current application areas and research topics of fuel cells and batteries. It deals with the design and functionality of electrochemical energy conversion and storage devices and provides knowledge about materials, cell designs, measurement methods, data analysis and modelling. The lecture and most slides are in German.

Organizational issues
https://ilias.studium.kit.edu/goto.php?target=crs_2193746&client_id=produktiv

T 3.18 Course: Bayesian Inverse Problems with Connections to Machine Learning [T-MATH-112842]

Responsible: TT-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 scale	Recurrence	Expansion	Version
Oral examination	4	Grade to a third	Each summer term	1 terms	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

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 scale	Recurrence	Version
Oral examination	5	Grade to a third	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 scale	Version
Written examination	6	Grade to a third	1

Events					
WT 23/24	2214010	Biopharmaceutical Purification Processes	3 SWS	Lecture / 🗣	Hubbuch, Franzreb
WT 23/24	2214011	Exercises on Biopharmaceutical Purification Processes (2214010)	1 SWS	Practice / 🗣	Hubbuch, Franzreb
Exams					
WT 23/24	7223011	Biopharmaceutical Purification Processes			Hubbuch

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
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 scale	Recurrence	Version
Oral examination	5	Grade to a third	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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0157500	Boundary and Eigenvalue Problems	4 SWS	Lecture	Lewintan
ST 2024	0157510	Tutorial for 0157500 (Boundary and Eigenvalue Problems)	2 SWS	Practice	Lewintan
Exams					
WT 23/24	0100032	Boundary and Eigenvalue Problems			Anapolitanos, Lamm, Hundertmark, Liao, Lewintan

Below you will find excerpts from events related to this course:

V Boundary and Eigenvalue Problems

Lecture (V)

0157500, SS 2024, 4 SWS, Open in study portal

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 scale	Recurrence	Version
Oral examination	8	Grade to a third	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 scale	Version
Oral examination	8	Grade to a third	1

T 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 scale	Version
Oral examination	4	Grade to a third	1

Exams			
WT 23/24	7700029	Brownian Motion	Bäuerle

Prerequisites
none

T 3.26 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 scale	Version
Written examination	8	Grade to a third	1

Events					
WT 23/24	0105300	Classical Methods for Partial Differential Equations	4 SWS	Lecture	Lewintan, Henninger
WT 23/24	0105310	Tutorial for 0105300 (Classical Methods for Partial Differential Equations)	2 SWS	Practice	Lewintan, Henninger
Exams					
WT 23/24	7700045	Classical Methods for Partial Differential Equations			Reichel, Anapolitanos, Lamm, Hundertmark, Lewintan

T 3.27 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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Events					
WT 23/24	2400158	Introduction to Artificial Intelligence	3 SWS	Lecture / Practice (/ 🗣	Neumann, Friederich
Exams					
WT 23/24	7500321	Introduction to Artificial Intelligence with Additional Performances			Neumann, Friederich

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.28 Course: Combinatorics [T-MATH-105916]

Responsible: Prof. Dr. Maria Aksenovich
Organisation: KIT Department of Mathematics
Part of: M-MATH-102950 - Combinatorics

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	see Annotations	3

Events					
ST 2024	0150300	Combinatorics	4 SWS	Lecture	Aksenovich, Clemen, Liu, Winter
ST 2024	0150310	Tutorial for 0150300 (Combinatorics)	2 SWS	Practice	Aksenovich, Clemen

Prerequisites
none

Annotation
The course is offered every second year.

Below you will find excerpts from events related to this course:

V Combinatorics

0150300, SS 2024, 4 SWS, Open in study portal

Lecture (V)

Content
Combinatorics is an area of mathematics primarily concerned with counting finite structures such as sets, groups, and graphs. While combinatorial problems are often very basic and easy to describe, solving them requires special knowledge and skills. This course is devoted to main concepts and techniques in combinatorics. These include counting principles such as inclusion-exclusion and bijective mappings, twelvefold way, generating functions, arrangements, Young tableaux, partitions, recursions, partially ordered sets, extremal set theory, and combinatorial designs.

3.29 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2232010	Fundamentals of Combustion Technology	2 SWS	Lecture / 🗣	Trimis
WT 23/24	2232011	Exercises for 2232010 Fundamentals of Combustion Technology	1 SWS	Practice / 🗣	Trimis, und Mitarbeiter
Exams					
WT 23/24	7231201	Combustion Technology			Trimis
ST 2024	7231201	Combustion Technology			Trimis

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 3.30 Course: Comparison Geometry [T-MATH-105917]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-102940 - Comparison Geometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Prerequisites
Keine

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 scale	Version
Oral examination	8	Grade to a third	1

T 3.32 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 scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

T 3.33 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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each term	1

Events					
WT 23/24	2245020	Computational Fluid Dynamics	2 SWS	Lecture / 🗣	Nirschl, und Mitarbeiter
WT 23/24	2245021	Exercises for 2245020 Computational Fluid Dynamics	1 SWS	Practice / 🗣	Nirschl, und Mitarbeiter
Exams					
WT 23/24	7291020	Computational Fluid Dynamics			Nirschl
ST 2024	7291932	Computational Fluid Dynamics			Nirschl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Learning control is a written examination lasting 90 minutes.

Prerequisites
None

T 3.34 Course: Computational Fluid Dynamics and Simulation Lab [T-MATH-113373]

Responsible: PD Dr. Mathias Krause
PD Dr. Gudrun Thäter

Organisation: KIT Department of Mathematics

Part of: M-MATH-106634 - Computational Fluid Dynamics and Simulation Lab

Type	Credits	Grading scale	Version
Examination of another type	4	Grade to a third	1

Events					
ST 2024	0161700	Computational Fluid Dynamics and Simulation Lab	4 SWS	Practical course	Thäter, Krause, Simonis

Prerequisites
none

T 3.35 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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	2424570	Computer structures	3 SWS	Lecture / 🗣	Karl
Exams					
WT 23/24	7500034	Computer Architecture			Karl

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.36 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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24081	Computergrafik	4 SWS	Lecture / 🗣	Dachsbacher, Bretl
Exams					
WT 23/24	7500430	Computer Graphics			Dachsbacher

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.37 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 scale	Recurrence	Version
Completed coursework	0	pass/fail	Each winter term	1

Events					
WT 23/24	24083	Übungen zu Computergrafik		Lecture / Practice (	Bretl, Dolp, Piochowiak
Exams					
WT 23/24	7500508	Computer Graphics			Dachsbacher

T 3.38 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.39 Course: Condensed Matter Theory I, Fundamentals [T-PHYS-102559]

Responsible: 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Garst
WT 23/24	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Garst, Masell

Legend: 🖥 Online, ✿ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.40 Course: Condensed Matter Theory I, Fundamentals and Advanced Topics [T-PHYS-102558]

Responsible: 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 scale	Version
Oral examination	12	Grade to a third	1

Events					
WT 23/24	4024011	Condensed Matter Theory I	4 SWS	Lecture / 🗣	Garst
WT 23/24	4024012	Exercises to Condensed Matter Theory I	2 SWS	Practice / 🗣	Garst, Masell

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.41 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals [T-PHYS-104591]

Responsible: Prof. Dr. Markus Garst
PD 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Gornyi, Poboiko, Scoquart

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

3.42 Course: Condensed Matter Theory II: Many-Body Systems, Fundamentals and Advanced Topics [T-PHYS-102560]

Responsible: Prof. Dr. Markus Garst
PD 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 scale	Version
Oral examination	12	Grade to a third	1

Events					
ST 2024	4024111	Condensed Matter Theory II: Many-Body Theory	4 SWS	Lecture / 🗣	Gornyi
ST 2024	4024112	Exercises to Condensed Matter Theory II	2 SWS	Practice / 🗣	Gornyi, Poboiko, Scoquart

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.43 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0159400	Continuous Time Finance	4 SWS	Lecture	Fasen-Hartmann, Göll
ST 2024	0159410	Tutorial for 0159400 (Continuous Time Finance)	2 SWS	Practice	Fasen-Hartmann
Exams					
WT 23/24	77220	Continuous Time Finance			Bäuerle

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

Below you will find excerpts from events related to this course:

V Continuous Time Finance

0159400, SS 2024, 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 3.44 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 scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 3.45 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.46 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 scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Competence Certificate
oral exam (ca. 20-30 min)

Prerequisites
none

T 3.47 Course: Deep Learning and Neural Networks [T-INFO-109124]

Responsible: Prof. Dr. Jan Niehues
Organisation: KIT Department of Informatics
Part of: M-INFO-104460 - Deep Learning and Neural Networks

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	2400024	Deep Learning and Neural Networks	4 SWS	Lecture / 🗣	Niehues, Waibel
Exams					
WT 23/24	7500259	Deep Learning and Neural Networks			Waibel
ST 2024	7500044	Deep Learning and Neural Networks			Niehues, Waibel

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-INFO-101383 - Neural Networks must not have been started.

T 3.48 Course: Differential Geometry [T-MATH-102275]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-101317 - Differential Geometry

Type	Credits	Grading scale	Recurrence	Version
Written examination	8	Grade to a third	Each summer term	1

Events					
ST 2024	0100300	Differential Geometry	4 SWS	Lecture	Sorcar
ST 2024	0100310	Tutorial for 0100300 (Differential Geometry)	2 SWS	Practice	Kupper, Sorcar

Below you will find excerpts from events related to this course:

V Differential Geometry

0100300, SS 2024, 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 3.49 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 scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 3.50 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 scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	1

Events					
WT 23/24	0108400	Finanzmathematik in diskreter Zeit	4 SWS	Lecture / 🗣	Bäuerle
WT 23/24	0108500	Übungen zu 0108400 (Finanzmathematik in Diksreter Zeit)	2 SWS	Practice / 🗣	Bäuerle
Exams					
WT 23/24	0100025	Discrete Time Finance			Bäuerle
WT 23/24	6700054	Discrete Time Finance			Bäuerle

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written exam of 2h.

Prerequisites
none

Recommendation
The contents of the module „Probability theory“ are strongly recommended.

3.51 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 3.52 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 3.53 Course: Elective Module - Subject, Body, Individual: the Other Side of Sustainability - Self Assignment BeNe [T-ZAK-112349]

Organisation:

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation
The content of the Basics Module is helpful.

T 3.54 Course: Elective Module - Sustainability Assessment of Technology - Self Assignment BeNe [T-ZAK-112348]

Organisation:

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation
The content of the Basics Module is helpful.

T 3.55 Course: Elective Module - Sustainability in Culture, Economy and Society - Self Assignment BeNe [T-ZAK-112350]

Organisation:

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation
The content of the Basics Module is helpful.

T 3.56 Course: Elective Module - Sustainable Cities and Neighbourhoods - Self Assignment BeNe [T-ZAK-112347]

Organisation: University

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate
Examination of another kind according to § 7 section 7 in the form of a presentation in the selected course.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation
The content of the Basics Module is helpful.

T 3.57 Course: Electromagnetics and Numerical Calculation of Fields [T-ETIT-100640]

Responsible: Prof. Dr.-Ing. Thomas Zwick
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100386 - Electromagnetics and Numerical Calculation of Fields

Type	Credits	Grading scale	Recurrence	Version
Written examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	2308263	Electromagnetics and Numerical Calculation of Fields	2 SWS	Lecture / 🗣	Pauli
WT 23/24	2308265	Exercise for 2308263 Electromagnetics and Numerical Calculation of Fields	1 SWS	Practice / 🗣	Pauli, Giroto de Oliveira
Exams					
WT 23/24	7308263	Electromagnetics and Numerical Calculation of Fields			Pauli

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

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

Prerequisites
none

Recommendation
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 scale	Version
Oral examination	10	Grade to a third	1

Events					
WT 23/24	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke
WT 23/24	4021012	Exercises to Electronic Properties of Solids I	1 SWS	Practice / 🗣	Le Tacon, Willke

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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	4021011	Electronic Properties of Solids I	4 SWS	Lecture / 🗣	Le Tacon, Willke

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	4021111	Electronic properties of solids II	2 SWS	Lecture / 🗣	Ustinov
ST 2024	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 scale	Version
Oral examination	4	Grade to a third	1

Events					
ST 2024	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: Dr. Gabriele Link
Organisation: KIT Department of Mathematics
Part of: M-MATH-106473 - Ergodic Theory

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Exams			
WT 23/24	7700114	Ergodic Theory	Link
ST 2024	7700114	Ergodic Theory	Link

Competence Certificate
Oral examination of ca. 20-30 minutes.

Prerequisites
none

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

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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0105900	Evolution equations	4 SWS	Lecture	Schnaubelt
WT 23/24	0105910	Tutorial for 0105900 (Evolution Equations)	2 SWS	Practice	Schnaubelt
Exams					
WT 23/24	7700132	Evolution Equations			Schnaubelt

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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

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 scale	Recurrence	Version
Oral examination	4	Grade to a third	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 scale	Version
Oral examination	4	Grade to a third	2

Events					
ST 2024	0155600	**Extremwerttheorie**	2 SWS	Lecture	Fasen-Hartmann
ST 2024	0155610	**Übungen zu 0155600 (Extremwerttheorie)**	1 SWS	Practice	Fasen-Hartmann

T 3.67 Course: Finite Element Methods [T-MATH-105857]

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-102891 - Finite Element Methods

Type	Credits	Grading scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0110300	Finite Element Methods	4 SWS	Lecture	Rieder
WT 23/24	0110310	Tutorial for 0110300 (Finite Element Methods)	2 SWS	Practice	Rieder
Exams					
WT 23/24	7700089	Finite Element Methods			Rieder

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 scale	Version
Oral examination	8	Grade to a third	2

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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24086	Formale Systeme	4 SWS	Lecture / Practice (	Beckert, Ulbrich, Weigl
Exams					
WT 23/24	7500036	Formal Systems			Beckert
ST 2024	7500009	Formal Systems			Beckert

T 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 scale	Recurrence	Version
Oral examination	3	Grade to a third	Once	1

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 scale	Recurrence	Version
Oral examination	6	Grade to a third	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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Exams			
WT 23/24	7700135	Fractal Geometry	Winter

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 scale	Recurrence	Version
Written examination	8	Grade to a third	Each winter term	3

Events					
WT 23/24	0104800	Functional Analysis	4 SWS	Lecture / 🗣	Frey
WT 23/24	0104810	Tutorial for 0104800 (Functional Analysis)	2 SWS	Practice / 🗣	Frey
Exams					
WT 23/24	0100047	Functional Analysis			Lamm, Hundertmark, Kunstmann, Schnaubelt, Frey, Liao

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Written examination of 120 minutes.

Prerequisites
none

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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Exams			
WT 23/24	7700117	Functional Data Analysis	Ebner

Competence Certificate
Oral examination of ca. 25 minutes.

Prerequisites
none

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

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 scale	Version
Oral examination	8	Grade to a third	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 scale	Version
Oral examination	6	Grade to a third	1

T 3.77 Course: Fuzzy Sets [T-INFO-101376]

Responsible: Prof. Dr.-Ing. Uwe Hanebeck
Organisation: KIT Department of Informatics
Part of: M-INFO-100839 - Fuzzy Sets

Type	Credits	Grading scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Exams			
WT 23/24	7500011	Fuzzy Sets	Pfaff

T 3.78 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 scale	Version
Oral examination	4	Grade to a third	3

Events					
ST 2024	0161400	Generalisierte Regressionsmodelle	2 SWS	Lecture	Klar
ST 2024	0161410	Übungen zu 0161400 (generalisierte Regressionsmodelle)	1 SWS	Practice	Klar

T 3.79 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Exams			
WT 23/24	7700140	Geometric Analysis	Lamm

Prerequisites
none

T 3.80 Course: Geometric Group Theory [T-MATH-105842]

Responsible: Prof. Dr. Frank Herrlich
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 scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	1

Events					
ST 2024	0153300	Geometric Group Theory	4 SWS	Lecture	Link
ST 2024	0153310	Tutorial for 0153300 (Geometric Group Theory)	2 SWS	Practice	Link
Exams					
WT 23/24	7700028	Geometric Group Theory			Llosa Isenrich

Below you will find excerpts from events related to this course:

V Geometric Group Theory

0153300, SS 2024, 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.

3.81 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0102900	Geometric Group Theory II	4 SWS	Lecture	Llosa Isenrich
WT 23/24	0102910	Tutorial for 0102900 (Geometric Group Theory II)	2 SWS	Practice	Llosa Isenrich
Exams					
WT 23/24	7700133	Geometric Group Theory II			Llosa Isenrich

T 3.82 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 scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 3.83 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 3.84 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.85 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 scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 3.86 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 scale	Recurrence	Version
Written examination	8	Grade to a third	Irregular	2

Events					
WT 23/24	0104500	Graph Theory	4 SWS	Lecture	Aksenovich, Clemen, Winter
WT 23/24	0104510	Tutorial for 0104500 (Graph Theory)	2 SWS	Practice	Aksenovich, Clemen
Exams					
WT 23/24	7700038	Graph Theory			Aksenovich

Prerequisites
None

Below you will find excerpts from events related to this course:

V Graph Theory

0104500, WS 23/24, 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 3.87 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 scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

T 3.88 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 scale	Version
Oral examination	8	Grade to a third	1

Exams			
WT 23/24	7700115	Harmonic Analysis	Frey, Tolksdorf

T 3.89 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 scale	Version
Oral examination	8	Grade to a third	1

Exams			
WT 23/24	7700120	Harmonic Analysis 2	Kunstmann

Competence Certificate
oral examination of ca. 30 minutes.

Prerequisites
none

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

T 3.90 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 scale	Version
Oral examination	4	Grade to a third	2

Events					
WT 23/24	2260020	Heat Transfer II	2 SWS	Lecture / 🗣	Wetzel, Dietrich
Exams					
WT 23/24	7280031	Heat Transfer II			Wetzel
ST 2024	7280031	Heat Transfer II			Wetzel

Legend: 🖥 Online, ✲ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.91 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	2232210	High Temperature Process Engineering	2 SWS	Lecture / 🗣	Stapf
ST 2024	2232211	High Temperature Process Engineering - Exercises	1 SWS	Practice / 🗣	Stapf, und Mitarbeiter
Exams					
WT 23/24	7231001	High Temperature Process Engineering			Stapf
ST 2024	7231001	High Temperature Process Engineering			Stapf

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Prerequisites
None

T 3.92 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.93 Course: In-depth Module - Doing Culture - Self Assignment BAK [T-ZAK-112655]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate

At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

Prerequisites

Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation

The content of the Basic Modul is helpful.

T 3.94 Course: In-depth Module - Global Cultures - Self Assignment BAK [T-ZAK-112658]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate

At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

Prerequisites

Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation

The content of the Basic Modul is helpful.

T 3.95 Course: In-depth Module - Media & Aesthetics - Self Assignment BAK [T-ZAK-112656]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate

At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

Prerequisites

Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation

The content of the Basic Modul is helpful.

T 3.96 Course: In-depth Module - Spheres of Life - Self Assignment BAK [T-ZAK-112657]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate
At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation
The content of the Basic Modul is helpful.

T 3.97 Course: In-depth Module - Technology & Responsibility - Self Assignment BAK [T-ZAK-112654]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Examination of another type	3	Grade to a third	1

Competence Certificate

At least two presentations must be given: An examination of another kind according to § 5 section 3 (3) in the form of a presentation in one of the chosen courses (3 ECT).
In a third seminar, either (a) a presentation is held (preliminary study achievement) which remains not graded and a topic-related term paper is submitted or (b) a written exam is taken.
The three courses can be selected individually from the 5 thematic blocks or – in exceptional cases and according to the agreement with the responsible lecturer – all three courses can be selected from one block in the sense of a specialization.
In addition, an oral examination is taken, which relates to the content of two of the chosen three courses.

Prerequisites

Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Annotation

The content of the Basic Modul is helpful.

T 3.98 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 3.99 Course: Information Security [T-INFO-112195]

Responsible: Prof. Dr. Jörn Müller-Quade
Organisation: KIT Department of Informatics
Part of: M-INFO-106015 - Information Security

Type	Credits	Grading scale	Recurrence	Version
Written examination	5	Grade to a third	Each summer term	2

Events					
ST 2024	2400199	Informationssicherheit	3 SWS	Lecture / Practice (	Müller-Quade, Strufe, Hartenstein, Wressnegger
Exams					
WT 23/24	7500003	Information Security			Wressnegger, Müller-Quade, Strufe

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-INFO-101371 - Security must not have been started.

T 3.100 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Events					
ST 2024	0160510	Übungen zu 0160500 (Integralgleichungen)	2 SWS	Practice	Hettlich

T 3.101 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 scale	Version
Written examination	8	Grade to a third	1

Events					
WT 23/24	0105000	Internetseminar für Evolutionsgleichungen	2 SWS	Lecture / 🗣	Schnaubelt, Kunstmann, Frey, Tolksdorf
Exams					
WT 23/24	7700134	Internet Seminar for Evolution Equations			Tolksdorf, Frey, Kunstmann, Schnaubelt

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, × Cancelled

Competence Certificate
oral examination of ca. 30 minutes

Prerequisites
none

T 3.102 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 scale	Version
Completed coursework	10	pass/fail	1

T 3.103 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 scale	Version
Oral examination	3	Grade to a third	1

Prerequisites
none

T 3.104 Course: Introduction to Aperiodic Order [T-MATH-110811]

Responsible: Prof. Dr. Tobias Hartnick
Organisation: KIT Department of Mathematics
Part of: M-MATH-105331 - Introduction to Aperiodic Order

Type	Credits	Grading scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 3.105 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 scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	6

Events					
WT 23/24	2400158	Introduction to Artificial Intelligence	3 SWS	Lecture / Practice (/ 🗣	Neumann, Friederich
Exams					
WT 23/24	7500136	Introduction to Artificial Intelligence			Friederich, Neumann
ST 2024	7500058	Introduction to Artificial Intelligence			Neumann, Friederich

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-INFO-101356 - Cognitive Systems must not have been started.

T 3.106 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 scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Events					
WT 23/24	0100024	Introduction to Convex Integration	2 SWS	Lecture	Zillinger
Exams					
WT 23/24	7700113	Introduction to Convex Integration			Zillinger

Competence Certificate
oral examination of approx. 30 minutes

Prerequisites
none

Recommendation
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

T 3.107 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	4022021	Introduction to Cosmology	2 SWS	Lecture / 🗣	Drexlin, Lokhov
WT 23/24	4022022	Exercises to Introduction to Cosmology	1 SWS	Practice / 🗣	Drexlin, Lokhov, Huber

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 23/24, 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 3.108 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Exams			
WT 23/24	7700119	Introduction to Dynamical Systems	de Rijk

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 3.109 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 scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 3.110 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 scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Irregular	1 terms	1

Competence Certificate
The module examination takes the form of an oral examination of approx. 25 minutes.

Prerequisites
none

Recommendation
The module *Functional Analysis* is strongly recommended.

T 3.111 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 scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 3.112 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

3.113 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 scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral examination of circa 30 minutes

Prerequisites
none

Recommendation
The course "Classical Methods for Partial Differential Equations" should be studied beforehand.

T 3.114 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	0155450	Introduction to Kinetic Theory	2 SWS	Lecture / Blended	Frank
WT 23/24	0155460	Tutorial for 0155450 (Introduction to Kinetic Theory)	1 SWS	Practice	Frank
Exams					
WT 23/24	7700078	Introduction to Kinetic Theory			Frank

Legend: Online, Blended (On-Site/Online), On-Site, Cancelled

Prerequisites
none

Below you will find excerpts from events related to this course:

V Introduction to Kinetic Theory
0155450, WS 23/24, 2 SWS, Language: English, Open in study portal

Lecture (V)
Blended (On-Site/Online)

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.

Organizational issues
The course will be offered in flipped classroom format. Flipped classroom means that the lectures will be made available as videos. We will regularly meet for tutorials and discussion sessions.

T 3.115 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 scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral examination of circa 30 minutes

Prerequisites
none

Recommendation
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" should be studied beforehand.

3.116 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 scale	Recurrence	Version
Completed coursework	3	pass/fail	Each summer term	1

Events					
ST 2024	0169000	Einführung in Python	1 SWS	Lecture	Weiß

T 3.117 Course: Introduction to Python - Programming Project [T-MATH-111851]

Responsible: Dr. Daniel Weiß
Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	1	pass/fail	Each summer term	1

3.118 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 scale	Version
Oral examination	8	Grade to a third	2

Events					
ST 2024	0165000	Einführung in das Wissenschaftliche Rechnen	3 SWS	Lecture	Wieners
ST 2024	0165010	Praktikum zu 0165000 (Einführung in das Wissenschaftliche Rechnen)	3 SWS	Practical course	Wieners

T 3.119 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Competence Certificate
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Recommendation
The contents of the module "Probability Theory" are strongly recommended. The module "Continuous Time Finance" is recommended.

3.120 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0105100	Inverse Problems	4 SWS	Lecture / 🗣	Griesmaier
WT 23/24	0105110	Tutorial for 0105100 (Inverse Problems)	2 SWS	Practice / 🗣	Griesmaier
Exams					
WT 23/24	7700131	Inverse Problems			Griesmaier

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.121 Course: IT Security [T-INFO-112818]

Responsible: Prof. Dr. Hannes Hartenstein
Prof. Dr. Jörn Müller-Quade
Prof. Dr. Thorsten Strufe
TT-Prof. Dr. Christian Wressnegger

Organisation: KIT Department of Informatics

Part of: M-INFO-106315 - IT Security

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	2

Events					
WT 23/24	2400010	IT Security	4 SWS	Lecture / Practice (/ 🗣	Müller-Quade, Strufe, Wressnegger, Hartenstein
Exams					
WT 23/24	7500038	IT Security			Müller-Quade, Strufe, Wressnegger, Hartenstein

Legend: 🖥 Online, ⚄ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 90 minutes.

Prerequisites
None.

Recommendation
Students should be familiar with the content of the compulsory lecture "Informationssicherheit".

T 3.122 Course: Key Moments in Geometry [T-MATH-108401]

Responsible: Prof. Dr. Wilderich Tuschmann
Organisation: KIT Department of Mathematics
Part of: M-MATH-104057 - Key Moments in Geometry

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Prerequisites
none

T 3.123 Course: L2-Invariants [T-MATH-105924]

Responsible: Dr. Holger Kammeyer
Prof. Dr. Roman Sauer

Organisation: KIT Department of Mathematics

Part of: M-MATH-102952 - L2-Invariants

Type	Credits	Grading scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

T 3.124 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

T 3.125 Course: Lie-Algebras (Linear Algebra 3) [T-MATH-111723]

Organisation: KIT Department of Mathematics

Part of: M-MATH-105839 - Lie-Algebras (Linear Algebra 3)

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Prerequisites

none

T 3.126 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	24613	Localization of Mobile Agents	3 SWS	Lecture / 🗣	Hanebeck
Exams					
WT 23/24	7500020	Localization of Mobile Agents			Zea Cobo

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Localization of Mobile Agents
24613, SS 2024, 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
Prüfungsterminvorschläge und das Verfahren dazu sind auf der Webseite der Vorlesung zu finden.

Literature
Grundlegende Kenntnisse der linearen Algebra und Stochastik sind hilfreich.

3.127 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 scale	Version
Oral examination	5	Grade to a third	1

Prerequisites
none

T 3.128 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 scale	Version
Final Thesis	30	Grade to a third	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 3.129 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 scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 3.130 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 scale	Recurrence	Version
Oral examination	5	Grade to a third	Irregular	1

Events					
ST 2024	0102900	Mathematische Methoden der Bildgebung	2 SWS	Lecture	Rieder
ST 2024	0102910	Übungen zu 0102900 (mathematische Methoden der Bildgebung)	2 SWS	Practice	Rieder

Prerequisites
None

T 3.131 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 scale	Version
Oral examination	4	Grade to a third	2

Events					
WT 23/24	0109400	Mathematical Modelling and Simulation	2 SWS	Lecture	Thäter
WT 23/24	0109410	Tutorial for 0109400 (Mathematical modelling and simulation)	1 SWS	Practice	Thäter
Exams					
WT 23/24	7500115	Mathematical Modelling and Simulation in Practise			Thäter

Below you will find excerpts from events related to this course:

V Mathematical Modelling and Simulation

Lecture (V)

0109400, WS 23/24, 2 SWS, Language: English, Open in study portal

T 3.132 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 scale	Version
Oral examination	8	Grade to a third	2

Exams			
WT 23/24	7700094	Mathematical Statistics	Fasen-Hartmann

Prerequisites
none

T 3.133 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 3.134 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.135 Course: Medical Imaging Technology I [T-ETIT-113048]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106449 - Medical Imaging Technology I

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each winter term	1

Events					
WT 23/24	2305261	Medical Imaging Technology I	2 SWS	Lecture	Spadea
Exams					
WT 23/24	7305012	Medical Imaging Technology I			Spadea
ST 2024	7305261	Medical Imaging Technology I			Spadea

Competence Certificate
The examination takes place in form of a written examination lasting 60 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 3.136 Course: Medical Imaging Technology II [T-ETIT-113421]

Responsible: Prof. Dr.-Ing. Maria Francesca Spadea
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-106670 - Medical Imaging Technology II

Type	Credits	Grading scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Events					
ST 2024	2305262	Medical Imaging Technology II	2 SWS	Lecture / 🗣	Spadea
Exams					
ST 2024	7305262	Medical Imaging Technology II			Spadea

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The examination takes place in form of a written examination lasting 60 minutes. The course grade is the grade of the written exam.

Prerequisites
none

T 3.137 Course: Methods of Signal Processing [T-ETIT-100694]

Responsible: Prof. Dr.-Ing. Michael Heizmann
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100540 - Methods of Signal Processing

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2302113	Methods of Signal Processing	2 SWS	Lecture / 🗘	Wahls, Heizmann
WT 23/24	2302115	Methods of Signal Processing (Tutorial to 2302113)	1+1 SWS	Practice / 🗣	Wahls, Heizmann, Diaz Ocampo
Exams					
WT 23/24	7302113	Methods of Signal Processing			Wahls

Legend: 🖥 Online, 🗘 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.138 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
oral examination of circa 20 minutes

Prerequisites
none

3.139 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 scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Prerequisites
None

3.140 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 scale	Version
Oral examination	4	Grade to a third	1

Competence Certificate
oral exam (ca. 20 min)

Prerequisites
None

T 3.141 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.142 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Each summer term	1

Events					
ST 2024	4010041	Modern Experimental Physics I, Atoms, Nuclei and Molecules	4 SWS	Lecture / 🗣	Müller
ST 2024	4010042	Übungen zu Moderne Experimentalphysik I	2 SWS	Practice / 🗣	Müller, Hinz

Legend: 🖥 Online, Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Oral exam, approx. 45 min

Prerequisites
successful completion of the exercises

Modeled Conditions
The following conditions have to be fulfilled:

1. The following conditions have to be fulfilled:

T 3.143 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 23/24	4010051	Moderne Experimentalphysik II (Struktur der Materie)	4 SWS	Lecture / 🗣	Klute, Ustinov
WT 23/24	4010052	Übungen zu Moderne Experimentalphysik II	2 SWS	Practice / 🗣	Klute, Ustinov, Waßmer, Fischer

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Oral exam, approx. 45 min

Prerequisites
successful completion of the exercises

Modeled Conditions
The following conditions have to be fulfilled:

1. The following conditions have to be fulfilled:

T 3.144 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.145 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 scale	Version
Oral examination	3	Grade to a third	1

3.146 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 scale	Version
Oral examination	4	Grade to a third	1

Competence Certificate
Mündliche Prüfung im Umfang von ca. 20 Minuten.

Prerequisites
none

T 3.147 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	2400024	Deep Learning and Neural Networks	4 SWS	Lecture / 🗣	Niehues, Waibel
Exams					
WT 23/24	7500259	Deep Learning and Neural Networks			Waibel
ST 2024	7500044	Deep Learning and Neural Networks			Niehues, Waibel

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-INFO-109124 - Deep Learning and Neural Networks must not have been started.

T 3.148 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 3.149 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 scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	1

Events					
ST 2024	2303173	Nichtlineare Regelungssysteme	2 SWS	Lecture / 🗣	Kluwe
Exams					
WT 23/24	7303173	Nonlinear Control Systems			Kluwe

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.150 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0156500	Nonlinear Evolution Equations	4 SWS	Lecture	Schnaubelt

Below you will find excerpts from events related to this course:

V Nonlinear Evolution Equations

0156500, SS 2024, 4 SWS, Open in study portal

Lecture (V)

Content

Evolution equations describe the change in time of dynamical systems via an ordinary differential equation in a Banach or Hilbert space. In this lecture we study nonlinear and autonomous (time invariant) problems, whose main part is given by a generator of a linear, strongly continuous operator semigroup. In particular, we treat reaction diffusion systems and semilinear wave and Schrödinger equations.

Typical topics are existence and uniqueness, continuous dependence on data, blow-up versus global-in time existence, regularity, or the longtime behavior near equilibria. Many of the results and methods are inspired by the theory of ordinary differential equations (Analysis 4), though the presence of unbounded operators in Banach spaces leads to many new and deep difficulties and phenomena. Our approach essentially relies on a functional analytic way of thinking.

The moduls functional analysis and evolution equations are strongly recommended. The necessary contents of the latter lecture will be briefly recalled though.

T 3.151 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 scale	Version
Oral examination	3	Grade to a third	1

T 3.152 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 3.153 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 3.154 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 scale	Version
Oral examination	4	Grade to a third	2

Events					
WT 23/24	0162300	Nichtparametrische Statistik	2 SWS	Lecture	Trabs
WT 23/24	0162310	Übungen zu 0162300 (Nichtparametrische Statistik)	1 SWS	Practice	Trabs
Exams					
WT 23/24	00090	Nonparametric Statistics			Trabs

Competence Certificate
oral exam of ca. 20 minutes

T 3.155 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 scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

T 3.156 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 scale	Version
Oral examination	6	Grade to a third	1

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 3.157 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 scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral exam of ca. 20 minutes

Prerequisites
none

Recommendation
Some basic knowledge of Complex Analysis is strongly recommended.

T 3.158 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 scale	Recurrence	Version
Examination of another type	5	Grade to a third	Irregular	2

Prerequisites
none

T 3.159 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Exams			
WT 23/24	7700137	Numerical Linear Algebra in Image Processing	Grimm

Prerequisites
none

T 3.160 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 scale	Version
Written examination	8	Grade to a third	3

Events					
WT 23/24	0110700	Numerische Methoden für Differentialgleichungen	4 SWS	Lecture / 🗣	Wieners
WT 23/24	0110800	Übungen zu 0110700 (numerische Methoden für Differentialgleichungen)	2 SWS	Practice / 🗣	Wieners
Exams					
WT 23/24	00049	Numerical Methods for Differential Equations			Wieners

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

3.161 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 scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

T 3.162 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0160500	Integralgleichungen	4 SWS	Lecture	Hettlich

T 3.163 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 scale	Version
Oral examination	6	Grade to a third	1

T 3.164 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 scale	Version
Oral examination	8	Grade to a third	1

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 3.165 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.166 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 scale	Version
Oral examination	6	Grade to a third	1

Prerequisites
none

3.167 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 scale	Version
Oral examination	4	Grade to a third	1

Events					
ST 2024	0161600	Numerical Methods in Fluidmechanics	2 SWS	Lecture	Dörfler

Below you will find excerpts from events related to this course:

Numerical Methods in Fluidmechanics

Lecture (V)

0161600, SS 2024, 2 SWS, Language: English, Open in study portal

Content

Starting from basics we develop the continuum mechanical model that lead to the fundamental equations for incompressible flows. We will study in more detail potential flows, Stokes flows (on bounded or exterior domains) and (non-turbulent) Navier-Stokes flows. We will sketch existence theory and show how to get numerical solutions with the finite element method, including stability and error estimates.

T 3.168 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0107800	Numerical methods in mathematical finance	4 SWS	Lecture	Jahnke
WT 23/24	0107900	Tutorial for 0107800 (numerical methods for mathematical finance)	2 SWS	Practice	Jahnke, Kirn
Exams					
WT 23/24	6700028	Numerical Methods in Mathematical Finance			Jahnke

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 3.169 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0124000	Numerische Optimierungsmethoden	4 SWS	Lecture	Rieder
WT 23/24	0124010	Übungen zu 0124000 (numerische Optimierungsmethoden)	2 SWS	Practice	Rieder
Exams					
WT 23/24	7700126	Numerical Optimisation Methods			Rieder

T 3.170 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

3.171 Course: Optical Waveguides and Fibers [T-ETIT-101945]

Responsible: Prof. Dr.-Ing. Christian Koos
Organisation: KIT Department of Electrical Engineering and Information Technology
Part of: M-ETIT-100506 - Optical Waveguides and Fibers

Type	Credits	Grading scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
WT 23/24	2309464	Optical Waveguides and Fibers	2 SWS	Lecture / 🗣	Koos, N.N., Bao, Kelany
WT 23/24	2309465	Tutorial for 2309464 Optical Waveguides and Fibers	1 SWS	Practice / 🗣	Koos, N.N., Bao
Exams					
WT 23/24	7309464	Optical Waveguides and Fibers			Koos
ST 2024	7309464	Optical Waveguides and Fibers			Koos

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.172 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 scale	Recurrence	Version
Oral examination	3	Grade to a third	Each summer term	1

Events					
ST 2024	2303162	Optimale Regelung und Schätzung	2 SWS	Lecture / 🗣	Kluwe
Exams					
WT 23/24	7303162	Optimal Control and Estimation			Kluwe
ST 2024	7303162	Optimal Control and Estimation			Kluwe

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.173 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 scale	Version
Oral examination	4	Grade to a third	1

Prerequisites
none

T 3.174 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 scale	Version
Oral examination	5	Grade to a third	2

Competence Certificate
oral examination of approximately 30 minutes

Prerequisites
none

Recommendation
Some basic knowledge of finite dimensional optimization theory and functional analysis is desirable.

T 3.175 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 scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 23/24	2303183	Optimization of Dynamic Systems	2 SWS	Lecture / 🧩	Hohmann
WT 23/24	2303185	Optimization of Dynamic Systems (Tutorial to 2303183)	1 SWS	Practice / 🧩	N.N.
WT 23/24	2303851	Accompanying group tutorial for 2303183 Optimization of Dynamic Systems	1 SWS	Tutorial (/ 🧩	N.N.
Exams					
WT 23/24	7303183	Optimization of Dynamic Systems			Hohmann

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment consists of a written exam (120 min) taking place in the recess period.

Prerequisites
none

T 3.176 Course: Oral Exam - Supplementary Studies on Culture and Society [T-ZAK-112659]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Competence Certificate
An oral examination according to § 7 section 6 of approx. 45 minutes on the contents of two courses from In-depth Module.

Prerequisites
Prerequisite for the 'Oral Examination' is the successful completion of Modules 1 and 3 and the required elective sections in Module 2.

T 3.177 Course: Oral Exam - Supplementary Studies on Sustainable Development [T-ZAK-112351]

Organisation:

Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Oral examination	4	Grade to a third	1

Competence Certificate

An oral examination according to § 7 section 6 of approx. 45 minutes on the contents of two courses from Elective Module.

Prerequisites

A requirement for the Supplementary Course: Oral examination is the successful completion of the modules Basics Module and Specialisation Module and the required electives of Elective Module.

3.178 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 scale	Version
Oral examination	5	Grade to a third	1

T 3.179 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Each winter term	1

Events					
WT 23/24	4022031	Particle Physics I	3 SWS	Lecture / 🗣	Ferber
WT 23/24	4022032	Exercises to Particle Physics I	2 SWS	/ 🗣	Ferber, Chwalek

Legend: 🖥 Online, ❋ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.180 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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	2

Events					
ST 2024	24675	Pattern Recognition	4 SWS	Lecture / Practice (/ 🗣	Beyerer
Exams					
WT 23/24	7500111	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 2024, 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 3.181 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 scale	Version
Oral examination	5	Grade to a third	2

Prerequisites
none

T 3.182 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	2250130	Physical Foundations of Cryogenics	2 SWS	Lecture / 🗣	Grohmann
ST 2024	2250131	Physical Foundations of Cryogenics - Exercises	1 SWS	Practice / 🗣	Grohmann
Exams					
WT 23/24	7250130	Physical Foundations of Cryogenics			Grohmann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
None

T 3.183 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 scale	Version
Oral examination	5	Grade to a third	1

Events					
ST 2024	0152700	Der Poisson-Prozess	2 SWS	Lecture	Nestmann

Prerequisites
none

T 3.184 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.185 Course: Practice Module [T-ZAK-112660]

Responsible: Dr. Christine Mielke
Christine Myglas

Organisation:

Part of: M-ZAK-106235 - Supplementary Studies on Culture and Society

Type	Credits	Grading scale	Version
Completed coursework	4	pass/fail	1

Competence Certificate
Internship (3 ECT)
Report within the framework of the practical training (Length approx. 18,000 characters (incl. spaces) (1 ECT)

Prerequisites
none

Annotation
Knowledge from the Basic Module and the Elective Module is helpful.

T 3.186 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 scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 3.187 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Each winter term	1

Events					
ST 2024	2214110	Process Modeling in Downstream Processing	2 SWS	Lecture / 🗣	Franzreb
Exams					
WT 23/24	7223015	Process Modeling in Downstream Processing			Franzreb

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 3.188 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2245030	Processing of Nanostructured Particles	2 SWS	Lecture / 🗣	Nirschl
Exams					
WT 23/24	7291030	Processing of Nanostructured Particles			Nirschl
ST 2024	7291921	Processing of Nanostructured Particles			Nirschl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
None

T 3.189 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

Recommendation
The contents of the module 'Probability Theory' are strongly recommended.

T 3.190 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 scale	Recurrence	Version
Written examination	6	Grade to a third	Each summer term	1

Events					
ST 2024	24576	Real-Time Systems	4 SWS	Lecture / Practice (/ 🗣	Längle, Ledermann
Exams					
WT 23/24	750002	Real-Time Systems			Längle

Legend: 🖥 Online, 🔀 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

T 3.191 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 scale	Version
Oral examination	6	Grade to a third	1

Competence Certificate
oral exam of ca. 30 minutes

Prerequisites
none

T 3.192 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 scale	Recurrence	Expansion	Version
Oral examination	8	Grade to a third	Irregular	1 terms	1

Exams			
WT 23/24	7700121	Riemann Surfaces	Herrlich

Competence Certificate
Oral examination of ca. 30 minutes.

Prerequisites
none

T 3.193 Course: Robotics I - Introduction to Robotics [T-INFO-108014]

Responsible: Prof. Dr.-Ing. Tamim Asfour
Organisation: KIT Department of Informatics
Part of: M-INFO-100893 - Robotics I - Introduction to Robotics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	2424152	Robotics I - Introduction to Robotics	3/1 SWS	Lecture / 🗣	Asfour
Exams					
WT 23/24	7500106	Robotics I - Introduction to Robotics			Asfour
ST 2024	7500218	Robotik I - Einführung in die Robotik			Asfour

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
none.

T 3.194 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 scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	4

Events					
ST 2024	2400074	Robotics II: Humanoid Robotics	2 SWS	Lecture / 🗣	Asfour
Exams					
WT 23/24	7500211	Robotics II: Humanoid Robotics			Asfour
ST 2024	7500086	Robotics II: Humanoid Robotics			Asfour

Legend: 🖥 Online, ❂ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Recommendation
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 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)
On-Site

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.

Learning Objectives:

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.

Organizational issues
Die Erfolgskontrolle erfolgt in Form einer schriftlichen Prüfung im Umfang von i.d.R. 60 Minuten nach § 4 Abs. 2 Nr. 1 SPO.

Arbeitsaufwand: 90 h

Empfehlungen: Der Besuch der Vorlesungen *Robotik I – Einführung in die Robotik* und *Mechano-Informatik in der Robotik* wird empfohlen

Zielgruppe: **Modul für Master Informatik, Master Maschinenbau, Mechatronik und Informationstechnik, Elektrotechnik und Informationstechnik**

Literature
Weiterführende Literatur

Wissenschaftliche Veröffentlichungen zum Thema, werden auf der VL-Website bereitgestellt.

T 3.195 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 scale	Recurrence	Version
Written examination	3	Grade to a third	Each summer term	2

Events					
ST 2024	2400067	Robotics III - Sensors and Perception in Robotics	2 SWS	Lecture / 🗣	Asfour
Exams					
WT 23/24	7500207	Robotics III - Sensors and Perception in Robotics			Asfour
ST 2024	7500242	Robotics III - Sensors and Perception in Robotics			Asfour

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
The assessment is carried out as a written examination (§ 4 Abs. 2 No. 1 SPO) lasting 60 minutes.

Prerequisites
none.

Modeled Conditions
The following conditions have to be fulfilled:

1. The course T-INFO-101352 - Robotics III - Sensors in Robotics must not have been started.

Recommendation
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 2024, 2 SWS, Language: German/English, Open in study portal

Lecture (V)
On-Site

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.

Learning Obejctives:

Students know the main sensor principles used in robotics and understand the data flow from physical measurement through digitization to the use of the recorded data for feature extraction, state estimation and environmental modeling.

Students are able to propose and justify suitable sensor concepts for common tasks in robotics.

Organizational issues

Die Erfolgskontrolle erfolgt in Form einer schriftlichen Prüfung im Umfang von i.d.R. 60 Minuten nach § 4 Abs. 2 Nr. 1 SPO.

Modul für Master Maschinenbau, Mechatronik und Informationstechnik, Elektrotechnik und Informationstechnik

Empfehlungen: **Der Besuch der Vorlesung *Robotik I – Einführung in die Robotik* wird empfohlen**

Zielgruppe: Die Vorlesung richtet sich an Studierende der Informatik, der Elektrotechnik und des Maschinenbaus sowie an alle Interessenten an der Robotik.

Arbeitsaufwand: 90 h

Literature

Eine Foliensammlung wird im Laufe der Vorlesung angeboten.

Begleitende Literatur wird zu den einzelnen Themen in der Vorlesung bekannt gegeben.

T 3.196 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 3.197 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.198 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 3.199 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 scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral examination of approx. 30 minutes

Prerequisites
none

Recommendation
The courses "Classical Methods for Partial Differential Equations" and "Functional Analysis" are recommended.

3.200 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 scale	Recurrence	Version
Oral examination	3	Grade to a third	Irregular	1

Prerequisites
none

T 3.201 Course: Self-Booking-HOC-SPZ-ZAK-1-Graded [T-MATH-111515]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each term	1

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

Annotation
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 3.202 Course: Self-Booking-HOC-SPZ-ZAK-2-Graded [T-MATH-111517]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Examination of another type	2	Grade to a third	Each term	1

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

Annotation
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 3.203 Course: Self-Booking-HOC-SPZ-ZAK-5-Ungraded [T-MATH-111516]

Organisation: KIT Department of Mathematics

Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each term	1

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

Annotation

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 3.204 Course: Self-Booking-HOC-SPZ-ZAK-6-Ungraded [T-MATH-111520]

Organisation: KIT Department of Mathematics
Part of: M-MATH-102994 - Key Competences

Type	Credits	Grading scale	Recurrence	Version
Completed coursework	2	pass/fail	Each term	1

Self service assignment of supplementary stdues
This course can be used for self service assignment of grade aquired from the following study providers:

- House of Competence
- Sprachenzentrum
- Zentrum für Angewandte Kulturwissenschaft und Studium Generale

Annotation
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.

3.205 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

3.206 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 scale	Recurrence	Version
Examination of another type	3	Grade to a third	Each summer term	1

T 3.207 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 scale	Version
Completed coursework	3	pass/fail	1

Exams			
WT 23/24	7700048	Seminar Mathematics	Kühnlein

T 3.208 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 scale	Version
Written examination	6	Grade to a third	1

Events					
ST 2024	2302135	Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Lecture / 🗣	Wahls
ST 2024	2302136	Practice to 2303135 Signal Processing with Nonlinear Fourier Transforms and Koopman Operators	2 SWS	Practice / 🗣	Wahls

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
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 3.209 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 scale	Version
Oral examination	8	Grade to a third	2

Recommendation
Some basic knowledge of (elementary) linear functional analysis is strongly recommended.

T 3.210 Course: Software Engineering II [T-INFO-101370]

Responsible: Prof. Dr.-Ing. Anne Koziolek
Prof. Dr. Ralf Reussner

Organisation: KIT Department of Informatics

Part of: M-INFO-100833 - Software Engineering II

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24076	Software Engineering II	4 SWS	Lecture / 🗣	Reussner
Exams					
WT 23/24	7500054	Software Engineering II			Reussner

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Software Engineering II

Lecture (V)
On-Site

24076, WS 23/24, 4 SWS, Language: German, Open in study portal

Literature

Craig Larman, Applying UML and Patterns, 3rd edition, Prentice Hall, 2004. Weitere Literaturhinweise werden in der Vorlesung gegeben.

T 3.211 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 scale	Recurrence	Expansion	Version
Oral examination	6	Grade to a third	Irregular	1 terms	1

Events					
WT 23/24	0100018	Space and time discretization of nonlinear wave equations	3 SWS	Lecture	Hochbruck, Dörich
Exams					
WT 23/24	7700138	Space and Time Discretization of Nonlinear Wave Equations			Hochbruck, Dörich

Prerequisites
none

T 3.212 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
WT 23/24	0105600	Spatial Stochastics	4 SWS	Lecture	Hug
WT 23/24	0105610	Tutorial for 0105600 (Spatial Stochastics)	2 SWS	Practice	Hug
Exams					
WT 23/24	7700052	Spatial Stochastics			Last, Hug

Prerequisites
none

T 3.213 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 scale	Version
Oral examination	8	Grade to a third	1

Prerequisites
none

T 3.214 Course: Specialisation Module - Self Assignment BeNe [T-ZAK-112346]

Responsible: Christine Myglas
Organisation:
Part of: M-ZAK-106099 - Supplementary Studies on Sustainable Development

Type	Credits	Grading scale	Version
Examination of another type	6	Grade to a third	1

Competence Certificate

The monitoring occurs in the form of several supplementary courses, which usually comprise a presentation of the (group) project, a written elaboration of the (group) project as well as an individual term paper, if necessary with appendices (examination performances of other kind according to statutes § 5 section 3 No. 3 or § 7 section 7).

The presentation is usually with the accompanying practice partners, as well as the written paper.

Prerequisites

Active participation in all three mandatory components.

Self service assignment of supplementary stdues

This course can be used for self service assignment of grade aquired from the following study providers:

- Zentrum für Angewandte Kulturwissenschaft und Studium Generale
- ZAK Begleitstudium

Recommendation

Knowledge from 'Basic Module ' and 'Elective Module ' is helpful.

T 3.215 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0163700	Spectral Theory	4 SWS	Lecture	Frey
ST 2024	0163710	Tutorial for 0163700 (Spectral Theory)	2 SWS	Practice	Frey

Competence Certificate
Oral examination of approx. 30 minutes.

Prerequisites
none

Below you will find excerpts from events related to this course:

V Spectral Theory

0163700, SS 2024, 4 SWS, Open in study portal

Lecture (V)

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 3.216 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.217 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

3.218 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 scale	Version
Oral examination	8	Grade to a third	1

Competence Certificate
The module will be completed with an oral exam (approx. 30 min).

Prerequisites
none

Recommendation
The module "Introduction to Stochastics" is recommended. The module "Probability theory" is preferable.

T 3.219 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 scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2024	2250040	Statistical Thermodynamics	2 SWS	Lecture / 🗣	Enders
ST 2024	2250041	Statistical Thermodynamics - Exercises	1 SWS	Practice / 🗣	Enders

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Learning control is an oral examination lasting approx. 30 minutes.

Prerequisites
Thermodynamics III

T 3.220 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

T 3.221 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 scale	Version
Oral examination	4	Grade to a third	1

Prerequisites
none

T 3.222 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.223 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 scale	Version
Oral examination	8	Grade to a third	1

Events					
ST 2024	0152600	Stochastic Geometry	4 SWS	Lecture	Winter
ST 2024	0152610	Tutorial for 0152600 (Stochastic Geometry)	2 SWS	Practice	Winter

Below you will find excerpts from events related to this course:

V Stochastic Geometry

0152600, SS 2024, 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

T 3.224 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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24113	Stochastic Information Processing	3 SWS	Lecture / 🗣	Hanebeck, Frisch
Exams					
WT 23/24	7500031	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

24113, WS 23/24, 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 (gambichler@kit.edu) zu vereinbaren.

Literature

Weiterführende Literatur

Skript zur Vorlesung

T 3.225 Course: Stochastic Simulation [T-MATH-112242]

Responsible: TT-Prof. Dr. Sebastian Krumscheid
Organisation: KIT Department of Mathematics
Part of: M-MATH-106053 - Stochastic Simulation

Type	Credits	Grading scale	Recurrence	Version
Oral examination	5	Grade to a third	Each winter term	1

Events					
WT 23/24	0100027	Stochastic Simulation	2 SWS	Lecture	Krumscheid
Exams					
WT 23/24	7700109	Stochastic Simulation			Krumscheid

Competence Certificate
oral exam of ca. 30 min

Prerequisites
none

T 3.226 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Prerequisites
none

3.227 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 scale	Recurrence	Version
Written examination	5	Grade to a third	Each winter term	1

Events					
WT 23/24	2313720	Technical Optics	2 SWS	Lecture / 🗣	Neumann
WT 23/24	2313722	Technical Optics (Tutorial to 2313720)	1 SWS	Practice / 🗣	Neumann
Exams					
WT 23/24	7313720	Technical Optics			Neumann

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.228 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 scale	Version
Completed coursework	3	pass/fail	1

Exams			
WT 23/24	7700031	Technomathematical Seminar	Kühnlein

T 3.229 Course: Telematics [T-INFO-101338]

Responsible: Prof. Dr. Martina Zitterbart
Organisation: KIT Department of Informatics
Part of: M-INFO-100801 - Telematics

Type	Credits	Grading scale	Recurrence	Version
Written examination	6	Grade to a third	Each winter term	1

Events					
WT 23/24	24128	Telematics	3 SWS	Lecture / 🗣	Zitterbart, Kopmann, Seehofer, Mahrt
Exams					
WT 23/24	7500166	Telematics			Zitterbart

Legend: 🖥 Online, ⚙ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Below you will find excerpts from events related to this course:

V Telematics

24128, WS 23/24, 3 SWS, Language: German, 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 3.230 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 scale	Version
Oral examination	6	Grade to a third	1

Events					
WT 23/24	4023131	Theoretical Nanooptics	2 SWS	Lecture / 🗣	Garst, Fernandez Corbaton
WT 23/24	4023132	Exercises to Theoretical Nanooptics	1 SWS	Practice / 🗣	Garst, Fernandez Corbaton
Exams					
WT 23/24	7800126	Theoretical Nanooptics			Rockstuhl

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

3.231 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 scale	Version
Oral examination	6	Grade to a third	1

Events					
ST 2024	4023111	Theoretical Optics	2 SWS	Lecture / 🗣	Rockstuhl
ST 2024	4023112	Exercises to Theoretical Optics	1 SWS	Practice / 🗣	Rockstuhl, NN

Legend: 🖥 Online, ✥ Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Prerequisites
none

T 3.232 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 scale	Version
Written examination	6	Grade to a third	1

Events					
WT 23/24	2250030	Thermodynamics III	2 SWS	Lecture / 🗣	Enders
WT 23/24	2250031	Thermodynamics III - Exercises	1 SWS	Practice / 🗣	Enders, und Mitarbeiter
Exams					
WT 23/24	7200104	Thermodynamics III			Enders

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Learning control is a written examination lasting 90 minutes.

Prerequisites
None

T 3.233 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 scale	Version
Oral examination	4	Grade to a third	1

Events					
ST 2024	2250050	Thermodynamics of Interfaces	2 SWS	Lecture / 🗣	Enders

Legend: 🖥 Online, 🧩 Blended (On-Site/Online), 🗣 On-Site, ✕ Cancelled

Competence Certificate
Erfolgskontrolle ist eine mündliche Prüfung im Umfang von 30 Minuten.

3.234 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 scale	Version
Oral examination	4	Grade to a third	3

Events					
ST 2024	0161100	Time Series Analysis	2 SWS	Lecture	Gneiting
ST 2024	0161110	Tutorial for 0161100 (Time Series Analysis)	1 SWS	Practice	Gneiting

Below you will find excerpts from events related to this course:

Time Series Analysis

0161100, SS 2024, 2 SWS, Language: English, Open in study portal

Lecture (V)

Content

A time series is a sequence of data sequentially observed in time. The course provides an introduction to the theory and practice of statistical time series analysis. Topics covered include stationary and non-stationary stochastic processes, autoregressive and moving average (ARMA) models, model selection and estimation, state-space models and the Kalman filter, forecasting and forecast evaluation, and an outline of spectral techniques.

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 scale	Recurrence	Version
Oral examination	6	Grade to a third	Irregular	1

Prerequisites
none

T 3.236 Course: Topological Genomics [T-MATH-112281]

Responsible: Dr. Andreas Ott
Organisation: KIT Department of Mathematics
Part of: M-MATH-106064 - Topological Genomics

Type	Credits	Grading scale	Recurrence	Expansion	Version
Oral examination	3	Grade to a third	Irregular	1 terms	1

Competence Certificate
oral exam of ca. 20 min

Prerequisites
none

T 3.237 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 scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Prerequisites
none

T 3.238 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 scale	Version
Oral examination	6	Grade to a third	2

Competence Certificate
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

Recommendation
The following background is strongly recommended: Analysis 1-4.

T 3.239 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 scale	Recurrence	Version
Oral examination	4	Grade to a third	Irregular	1

Events					
ST 2024	0164400	Uncertainty Quantification	2 SWS	Lecture	Frank
ST 2024	0164410	Tutorial for 0164400 (Uncertainty quantification)	1 SWS	Practice	Frank

Prerequisites
none

Below you will find excerpts from events related to this course:

V Uncertainty Quantification

0164400, SS 2024, 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.

T 3.240 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 scale	Version
Oral examination	8	Grade to a third	1

T 3.241 Course: Wavelets [T-MATH-105838]

Responsible: Prof. Dr. Andreas Rieder
Organisation: KIT Department of Mathematics
Part of: M-MATH-102895 - Wavelets

Type	Credits	Grading scale	Recurrence	Version
Oral examination	8	Grade to a third	Irregular	1

Competence Certificate
Mündliche Prüfung im Umfang von ca. 30 Minuten.

Prerequisites
none