MASTER DEGREE COURSES OFFERED IN ENGLISH IN SUMMER SEMESTER 2019

- 0161100 Time Series Analysis
  Instructor: Bernhard Klar
  Weekly Hours: 2+1

  A time series is a series of observations taken sequentially over time. The lecture deals with the basic concepts of classical time series analysis:
  - Stationary time series
  - Trends and seasonality
  - Autocorrelation
  - Autoregressive models
  - ARMA models
  - Forecasting of time series
  - Spectral density and periodogram

  Prerequisites: An introductory course in probability and statistics.

- 0160400 Topics in Numerical Linear Algebra
  Instructor: Markus Neher
  Weekly Hours: 4+2

  This course resumes numerical methods for the solution of large linear systems of equations with sparse matrices and for the computation of eigenvalues of large matrices. It also provides an introduction to methods for computing matrix functions.

  Prerequisites: Fundamentals of numerical linear algebra.

- 0157600 Fourier analysis and its applications to PDEs
  Instructor: Xian Liao
  Weekly Hours:

  In this course we will introduce the theory of Fourier analysis and then provide its applications to some typical PDEs. The Fourier transform and the Littlewood-Paley decomposition techniques have shown their efficiency in the study of evolutionary equations. In particular, we will make use of the Littlewood-Paley theory to study the transport-diffusion equations, Navier-Stokes equations, and so on.

Prerequisites: Basic concepts from functional analysis.

- 0157400 Algebraic Topology I
  Instructor: Caterina Campagnolo
  Weekly Hours : 4+2

  This is a first course in algebraic topology, or how to use algebraic methods to tackle topological problems. The field is one of the biggest developments of mathematics in the twentieth century.

  At the beginner's level, algebraic topology separates naturally into the two broad topics of homology and homotopy. We introduce the fundamental group functor, with many examples and applications. Then we study covering theory. After that we pass to homology theory. The course covers the essentials of singular homology, including the axiomatic approach and the computational approach via cellular complexes. Fundamental ideas of homological algebra will be an important part of the course. A highlight at the end of the course is the effective computation of homology groups of cell complexes.

  Prerequisites: basic notions of set-theoretic topology (topological space, open, closed, connected, compact subsets, continuous functions, quotient topology); basic notions of group theory and modules.

- 0164400 Uncertainty Quantification
  Instructor: Martin Frank
  Weekly Hours: 2+1

  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.

Prerequisites: Numerical methods for differential equations

- 0161600/0161610 Numerical Methods in Fluid mechanics (2+1, 4 LP)
  Instructors: Willy Doerfler and Fabian Castelli
  Weekly Hours: 2+1

  Starting from basics we develop the continuum mechanical model that lead to the fundamental equations for incompressible and compressible flows. We will study in more detail potential flows, Stokes flows and (non-turbulent) Navier–Stokes flows. The numerical techniques we consider are the finite element method, the finite volume method and the discontinuous Galerkin method. As special applications we will consider particulate and electrokinetic flows as one will find for example in battery models.

  Prerequisites: Basic knowledge in partial differential equations and finite element methods.

- 0160800/0160810 Numerical Methods for Hyperbolic Equations
  Instructors: Willy Doerfler and Mariia Molochkova
  Weekly Hours: 3+1

  We present basic theory for equations in conservation form and the fundamental principle to derive numerical methods. As an application we focus on compressible flow equations and Maxwell equations. Contents: Derivation of equations in conservation form; Shocks, Rarefaction waves, weak solutions; Aspects of existence and regularity theory; Discretization of conservation laws with Finite Volume and Discontinuous Galerkin Methods; Applications

  Prerequisites: Basic knowledge in partial differential equations and finite element methods.

- 0163700 Spectral Theory
  Instructor: Peer Kunstmann
  Weekly Hours: 4+2

  The topic of this course is the spectral theory of linear operators in Banach spaces. Spectral theory plays a role in the investigation of partial differential equations in various fields. Central topics are properties of the spectrum, the study of eigenvalues and eigenvectors, properties of the resolvent map, decompositions of the underlying space in invariant subspaces, and existence of functional calculi that allow, e.g., algebraic calculations with operators. We shall study in particular spectrum and resolvents of bounded and unbounded operators, the Fourier transform, Fredholm operators and perturbation theory, the spectral theorem for self-adjoint operators in Hilbert spaces, and applications to differential operators and boundary value problems.

Prerequisites: Functional Analysis, basics of complex analysis and Lebesgue integration

- Numerical method for differential equations (seminar)
  Instructor: Christian Wieners
  Description: TBA

- 0100300 Differential Geometry
  Instructor: Wilderich Tuschmann
  Weekly Hours: 4+2

  Differential geometry is one of the most research-intensive areas of mathematics in recent decades. It has a long tradition that traces its development back well over a century. Its current prominence stems from its position at the crossroads of many active fields such as: topology, metric geometry, analysis, partial differential equations, Lie and other forms of group theory. Its influence spreads well beyond the confines of pure mathematics to interact with theoretical physics and extends to a multitude of practical applications as diverse as engineering, robotics and computer vision.

  The course will provide a thorough introduction to the basics of modern differential geometry, such as manifolds, tensors, bundles, Riemannian metrics, linear connections, covariant derivatives, parallel transport, geodesics, and curvature.

  Prerequisites: Students taking the course should have a good understanding of Linear Algebra 1,2 and Analysis 1,2,3.

- 0172100 Algebraic Methods in Combinatorics (seminar)
  Instructors: Maria Axenovich, Casey Tompkins

How many lines are defined by n non-collinear points in the plane? How many colors are needed to color points in $\mathbb{R}^n$ so that no two points at distance 1 have the same color? Can one edge-partition a clique on 10 vertices into three copies of a Petersen graph? We answer these and other questions in graph theory, combinatorial geometry, and combinatorial number theory using algebraic methods. Relevant lecture notes will be provided.

Prerequisites: knowledge of graph theory, linear algebra, abstract algebra.

See also http://www.math.kit.edu/vvz/seite/vvzkommend