MASTER DEGREE COURSES OFFERED IN ENGLISH IN WINTER SEMESTER 2019-20

- 0102650 Statistical Forecasting and Classification (seminar)
  Instructor: Tilmann Gneiting
  Weekly Hours: 2

- 0104500 Graph Theory
  Instructor: Maria Axenovich
  Weekly Hours: 4+2

  Graphs are basic 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 interconections. 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 paid in the problem classes. The final grade will be based on the written exam. Bonus points will be given for weekly or biweekly homework assignments.

  Prerequisites: Basic knowledge of linear algebra

- 0105300 Classical Methods for Partial Differential Equations
  Instructor: Michael Plum
  Weekly Hours: 4+2

  A differential equation is a relation between an unknown function (to be determined) and its derivatives. While for ordinary differential equations the unknown function depends on a single independent variable, it depends on several variables for partial differential equations. A huge variety of processes in science and technology is described by partial differential equations, which therefore belong to the most important objects of investigation in Applied Mathematics.

  The number of phenomena occurring in the context of partial differential equations, and the number of methods and techniques to investigate them, is by far too complex to be the content of a one semester course. The lecture course can therefore only be of an introductory type. Topics to be treated are e.g. the classical wave-, Poisson-, and heat equation, maximum principles, separation of variables, classification of quasilinear second-order equations and first-order systems, normal forms, a fixed-point approach for second-order hyperbolic equations. Strong emphasis will be put on many examples from physics and engineering.

The lecture course addresses students in their fifth semester (third year) or higher, with substantial knowledge in analysis and linear algebra. It is suitable for students of mathematics, and for students of other subjects who have strong mathematical interests. The lectures will be accompanied by exercise lessons. Attendance of these exercises is strongly recommended to all participants. As already mentioned, this lecture course can cover only a small portion of the overall topic of partial differential equations. Deeper knowledge can be aquired in further subsequent courses.

- 0105200 Introduction to ergodic theory and homogeneous dynamics
  Instructor: Igor Karasik
  Weekly hours: 3+1

  Ergodic theory studies the orbit structure of iterations of a measurable map in a statistical point of view. More generally, one considers the qualitative properties of actions of lcsc groups on measure spaces. This highly active field of mathematics is maturely connected to analysis, geometry and number theory and has an outreaching scope of applications even outside of Mathematics! This is an introductory course where we get familiarized with the basic concepts and ideas of ergodic theory which are relevant to a broad spectrum of mathematicians. After introducing the classical case of iterated transformation we generalize those ideas to handle the group case focusing on the abelian, nilpotent and $SL_2(R)$ cases. During the course, we will consider applications to number theory and geometry.

  Prerequisites: An introductory course in measure theory and in functional analysis; basic concepts in group theory.

- 0105360 Nonlinear Maxwell Equations
  Instructor: Roland Schnaubelt
  Weekly Hours: 4+2

  The Maxwell equations are the fundamental laws governing electro-magnetic phenomena. Constitutive relations describe the interaction between the fields and the material by determining the polarization or magnetization. We study nonlinear relations focussing on an instantaneous material response. The Maxwell system then becomes a quasilinear hyperbolic system. We first investigate the full space case. Here one can establish local wellposedness for initial values in H^3 by well-established energy methods. Problems on domains with boundary conditions (or interface problems) are much more demanding. We present very recent results and discuss the strategy of proof. We will further study blow-up phenomena and decay properties in the presence of an conductivity.

The lectures requires knowledge in functional analysis and basics of Sobolev spaces. Further tools will be discussed in the lectures, possibly without giving complete proofs.

- 0109400 Mathematical Modelling and Simulation
  Instructor: Gudrun Thäter
  Weekly Hours: 2+1

  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.

  During the lecture course there will be one lecture of a person from industry (before Christmas) and one excursion (at the end of the lecture course). To earn the credits you have to attend the lecture and finish the work on one project during the term in a group of 2-3 persons. The topic of the project is up to the choice of each group. The exam is an oral exam. You can check the contents in great detail on the following page: http://www.math.kit.edu/ianm2/lehre/mathmodelsim2018w/

  Prerequisites: There are no special prerequisites.

- 0111500 Algebraic Topology II
  Instructor: Caterina Campagnolo
  Weekly Hours : 4+2

  This course is the natural continuation of the Algebraic Topology course that took place in the Summer semester 2019. We deepen our study of homology theory, in particular by introducing cellular homology. We give the homological definition of the degree of a map and obtain some applications. We also define the Euler characteristic. Next we move to cohomology theory. This is the algebraic dual of homology theory, so that it shares many features with it, but it presents the big advantage of admitting a ring structure, with the cup-product as its multiplication. This will prove to be a very powerful invariant in distinguishing spaces that all previous topological invariants could not tell apart. Along the way we study some classical subjects of homological algebra, such as the Tor and the Ext functors. We will show the universal coefficient theorems and the Knneth formulas for homology and cohomology. Finally we reunite the two theories by proving the Poincar duality for closed manifolds.

Prerequisites : Basic knowledge of groups and rings, fundamental group, basics of homology theory (simplicial and singular homology, homotopy invariance, relative homology, long exact sequences, excision). Essentially the content of the Algebraic Topology course will be assumed.

- 0115800 Functions of Matrices
  Instructor: Volker Grimm
  Weekly Hours: 4+2

  This course deals with definitions and properties of matrix functions. Particularly, the approximation of functions of large sparse matrices times a vector by (rational) Krylov subspace methods is studied. Several applications will be discussed.

  Prerequisites: Numerical analysis, complex analysis.

- 0121300 Extremal set theory (seminar)
  Instructor: Maria Axenovich
  Weekly Hours: 2

  One of the classical questions in extremal set theory is "In an n-element set, what is the largest number of k-element subsets that can pairwise intersect one another?" These and other problems about finite sets will be addressed during the seminar. The main reference is a book by S. Yukna, additional literature will be provided.

- 0155450 Introduction to Kinetic Theory
  Instructor: Martin Frank
  Weekly hours: 2+1

  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.

Prerequisites: none
Recommended courses: Partial Differential Equations, Functional Analysis

- 0163500 Mathematical Methods in Quantum Mechanics I
  Instructor: Ioannis Anapolitanos
  Weekly Hours: 4+2

Quantum mechanics is one of the subjects in physics that has influenced Mathematics during the last century. For example, it has drastically influenced the development of Functional Analysis, Spectral Theory and

Operator Theory. Goal of this lecture series is to discuss how to investigate Quantum Mechanics from a mathematically rigorous point of view. This makes course having a different aspects than Quantum Mechanics courses from the Physics point of view. Contents include observable and self-adjointness (which requires more than what usually physicists consider as self-adjoint) , existence of dynamics of Schrdinger equations, spectral properties of Schdinger operators, the uncertainty principle, existence and stability of atoms. Note that the course will have a second part in summer semester and in the second part we will also cover some topics of actual research.

Prerequisites: Analysis, linear Algebra. It is recommended that you have taken functional analysis or that you take it parallel to the class. If you are not sure about your background please talk to me.

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