University of Bremen

## – Faculty 3 –

# Courses

# Summer Semester 2024

M.Sc. Industrial Mathematics & Data Analysis

M.Sc. Mathematics

M.Sc. Mathematik

M.Sc. Technomathematik

January 2024

This brochure summarizes almost all courses and lectures of the Master's programs Industrial Mathematics & Data Analysis, Mathematics, Mathematik (German-language), and Technomathematik (German-language) for the summer semester 2024. Further information can be found in the Course Catalog of the University of Bremen. There you will find, among other things, the language, the assignments to the individual modules, and the course codes. These information and all details can also be found in Stud.IP.

As you can see in the Course Catalog or in Stud.IP, all courses are usually assigned with an area of focus or specialization. This can also be found for all courses via *Fields of study* in Stud.IP. For the M.Sc. Industrial Mathematics & Data Analysis, these are **Data Analysis** as well as **Industrial Mathematics**. For the M.Sc. Mathematics and the M.Sc. Mathematik, these are **Algebra**, **Analysis**, **Numerical Analysis**, and **Statistics/Stochastics**.

At this point we would like to refer to the Arrival Guide for general questions as well as to Offers for International Students and Living on Campus for answers regarding living, housing, financial help, and scholarships.

# Contact

## Academic Advisory Office - Mathematics

Place to go for questions on study programs, planning, recognition of credits and exam results, study abroad, and examination regulations. Also responsible for the design of this brochure.

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# Contents

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Alphabetical ordering and the lecturers are responsible for the content of the descriptions

# Analytic and Discrete Convex Geometry

Course Code: 03-M-SP-15

Dr. Eugenia Saorín Gómez

Contact: esaoring@uni-bremen.de

## Description

Convex Geometry is, in its origins, the geometry of convex domains in Euclidean space. The theory surrounding it plays a central role in many branches of Mathematics, such as Discrete Mathematics, Functional and Harmonic Analysis, Linear Programming, PDEs, and, increasingly, also in the study of algorithms in Computer Science. According to C. Zong (see reference 14 in the literature list), Convex and Discrete Geometry, apart from being one of the most intuitive subjects in Mathematics, *has the characteristic that many of its hardest problems, such as the sphere packing problem or Borsuk's problem, can be explained, along with their conjectured answers, to a layman in a few minutes. However, proofs of the conjectured answers to some of these simply stated problems often have cost the best mathematicians decades or centuries of effort. More surprisingly, some of these commonly believed conjectures, whose truth seemed intuitively certain, were not true. [...]. Furthermore, there are problems in Convex and Discrete Geometry whose answers are so counterintuitive and strange that they can hardly be believed before reading their proofs.* The main aim of this course is to discuss some of these problems, along with some of their (eventually only partial) answers. For, we will deal with different analytic and discrete aspects of Convex Geometry, keeping the main focus on some of the above-mentioned problems. As an example of these problems, we briefly describe Borsuk's problem, which asks whether it is true, that any bounded set $X \subset \mathbb{R}^n$ can be partitioned into $n+1$ subsets $X_1, \ldots, X_{n+1}$ such that

$$\operatorname{diam} X_i < \operatorname{diam} X, \quad i = 1, 2, \ldots, n+1.$$

Here $\operatorname{diam} X$ denotes the diameter of $X$, i.e., as usual,

$$\operatorname{diam} X = \sup_{x,y \in X} ||x - y||.$$

It was widely believed, that the answer to the above question was YES. It is known, that for $n = 3$, the answer is indeed affirmative. Surprisingly, if the dimension $n$ of the space is large enough, the answer happens to be NO.

## Prerequisites

The course will be self-contained. Although knowledge about the theory of convex sets can be helpful, we only set the usual Linear Algebra and Analysis of the first to third/fourth semesters of a regular Bachelor's degree in Mathematics as prerequisites. Indeed, depending on the previous knowledge of the participants, the first three to four weeks will be devoted to the basic theory of convex sets in Euclidean space. We will introduce the essentials of convex sets, some of their (geo)metric properties, and some special families of those, such as polytopes; the space of convex and compact sets in $\mathbb{R}^n$; fundamental geometric magnitudes associated with convex and compact sets, as inradius, circumradius, diameter and (minimal and mean) width; rudiments on convex functions, especially the support function of a convex and compact set; and the fundamentals of (geometric) lattices and packings.

## Structure

The course will consist of three weekly units: two classroom lectures (4SWS) and one exercise session (2SWS). The precise schedule will be available in Stud.IP. Depending on the number of students, and upon agreement, there will be a combination of discussion of exercises and short presentations during the exercise sessions.

## Area of Specialization

Algebra, Data Analysis

## Examination and Formalities

There will be an oral exam at the end of the term.

## List of Literature


1. S. Artstein-Avidan, A. Giannopoulos and V. D. Milman, Asymtotic Geometric Analysis, Part I, AMS, 2015.

2 I. Bárány, Combinatorial Convexity, AMS, 2021.

2. A. Barvinok, A course in Convexity, AMS, 2002.

3. A. Barvinok, Integer points in polyhedra, EMS, 2008.

4. Y. D. Burago, V. A. Zalgaller, Geometric Inequalities, Springer, 1988.

5. J. Cassels, An Introduction to the Geometry of Numbers, 1971.
6. R. Gardner, Geometric Tomography (2nd Edition), Cambridge, 2006.
7. P. M. Gruber, Convex and Discrete Geometry, Springer, 2007.
8. P. M. Gruber and C. Lekkerkerker, Geometry of Numbers, 1987.
9. D. Hug and W. Weil, Lectures on Convex Geometry, Springer, 2020.
10. L. Lovász, An Algorithmic Theory of Numbers, Graphs, and Convexity, SIAM, 1986.
11. J. Matoušek, Lectures on Discrete Geometry, Springer, 2002.
12. R. Schneider, Convex Bodies: The Brunn-Minkowski Theory, (2nd Edition) Cambridge, 2013.
13. G. M. Ziegler, Lectures on Polytopes, Springer, 1995.
14. C. Zong, Strange Phenomena in Convex and Discrete Geometry, Springer, 1996.

# Differential Geometry

Course Code: 03-M-SP-34

Prof. Dr. Anke Pohl

Contact: apohl@uni-bremen.de

## Description

Differential geometry is not only an intrinsically beautiful research field with all its theorems and theories which put much of real analysis into a much cleaner, conceptual setting than it is possible within the classical flat situation of real vector spaces. Differential geometry also plays a fundamental role in an enormous number of fields. For example, it is essential for general relativity, for geodesy, for navigation, for robot control and its modeling, etc. Of course, differential geometry is also of enormous importance within mathematics. **In short: Differential geometry is useful and beautiful!**

The topics that we will cover include manifolds, vector bundles, embeddings and submersions, integral curves and flows, basics of Lie groups, differential forms and integration, Riemannian metrics, geodesics, connections, curvature. This course can be continued with master seminars, reading courses and can serve as a basis for master theses.

## Prerequisites

Solid mathematical knowledge to the extent of a bachelor's degree in mathematics.

## Structure

Weekly lectures (4 SWS) and weekly tutorials (2 SWS).

## Area of Specialization

Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

Exam: oral or written (will be decided upon in April 2024); coursework: successful completion of homework and active participation in tutorials.

## List of Literature

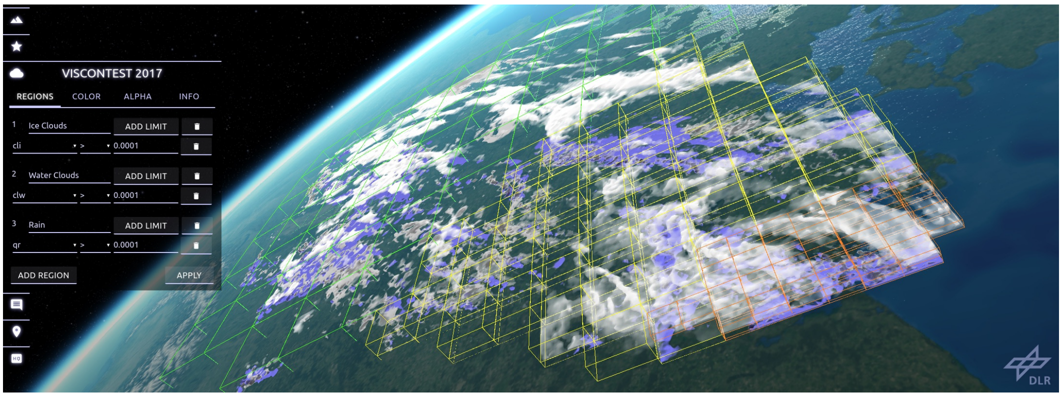
A list of references will be provided in Stud.IP.

# High-Performance Visualization

Course Code: 03-M-SP-12

Prof. Dr. Andreas Gerndt

Contact: gerndt@uni-bremen.de




## Description

In this lecture, the mathematical basics of scientific visualization are taught. It aims at methods for parallel post-processing of very large-scale scientific datasets. Such data occurs in plenty of scientific applications. It is created by simulations on high-performance supercomputers (e.g. to support climate research or analysis of flow fields at airfoils). It can also be the outcome of measurements as it occurs in Earth observation missions. To get any insight into the scientific results, first of all, a huge amount of raw data has to be processed to extract meaningful features. Those features can eventually be explored in interactive working environments. To enable real-time exploration at the end of the processing pipeline, again highly parallel and efficient methods are required. They have to be optimized for the execution on distributed computing clusters and high-end graphics cards. This lecture addresses foundational approaches of feature extraction, data processing, and efficient 3D visualization. Application examples are demonstrated with the Open Source software ParaView.

## Prerequisites

Students from Mathematics, Computer Science, and other relevant application domains (like Geo-science or Aerodynamics) can participate at the lecture. Background knowledge in Computer Graphics or High-Performance Computing is useful but not required. Programming skills e.g. in Python or C++ are also useful.

## Structure

The weekly lecture is given in English. The slides are in English as well and can be used as references. In the lectures, several topics are presented: Computer Graphics Primer, High-Performance Computing Primer, Visualization Pipeline, Data Representation and Reconstruction, Scalar Visualization, Color Mapping, Scalar Topology Extraction, Vector Field Processing, Particle Integration, Vector Field Topology, Tensor Field Visualization, Direct Volume Rendering, Parallel and Distributed Post-processing, Multi-Resolution and Data Streaming, In-situ Co-processing, Terrain Rendering, Atmosphere Visualization, Flow Visualization, Vortex Extraction, Multivariate Data Queries.

## Area of Specialization

Numerical Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

Application exercises and example datasets are provided to repeat the presented topics. Programming exercises can also be carried out as homework. The programming results should be submitted within two weeks after an exercise has been dispatched. They would then become part of the evaluation. The lecture eventually ends with an individual oral exam. An oral exam is also possible without programming exercises. The achievable amount of credit points would then be reduced. Consultation hours can be agreed on personal need.

## List of Literature

- A. C. Telea, "Data Visualization – Principles and Practice", 2. Edition, CRC Press, 2015 - E. W. Bethel, H. Childs, C. Hansen, "High Performance Visualization", CRC Press, 2013
- W. Schroeder, K. Martin, B. Lorensen, "The Visualization Toolkit", 4. Edition, Kitware, 2006
- C. Hansen, C. Johnson, "The Visualization Handbook", Elsevier Academic Press, 2005

## Mathematical Foundations of Machine Learning

Course Code: 03-M-SP-16

Prof. Dr. Peter Maaß, Dr. Matthias Beckmann

Contact: matthias.beckmann@uni-bremen.de

### Description

Machine learning is nowadays an integral component of intelligent systems for analyzing data in natural and engineering sciences. Machine learning algorithms are used in a wide variety of applications, such as in medicine, bioinformatics, natural language processing, speech recognition and computer vision, where it is difficult or infeasible to develop conventional algorithms to perform the needed tasks. For example, it allows to predict the binding behavior of complex molecules in drug design or to process a huge amount of sensor data in real time to pave the way for autonomous driving. This course gives an introduction into the mathematical foundations of machine learning and focuses on classical theory as well as the implementation of fundamental algorithms. Methods of deep learning will be briefly discussed towards the end of the course. In particular, the following topics will be covered: - Elements of statistical learning theory (PAC learning, No Free Lunch, VC theory), - Methods of supervised learning (classification, regression), - Kernel methods, - Generative models, - Methods of unsupervised learning (dimensionality reduction, cluster analysis), - Deep learning with neural networks. Among others, we will make use of tools from linear algebra, probability theory, statistics, functional analysis, (convex) optimization and approximation theory.

### Prerequisites

Basics from B.Sc. courses in Mathematics (calculus, linear algebra, numerical analysis, probability theory) and basic programming skills. In particular, participants are assumed to be familiar with the following standard concepts: - eigendecomposition/singular value decomposition of matrices, multivariate calculus, Landau symbols, - probability space, measurability, random variable, probability distribution, probability density function, expected value, joint probability, marginal probability, conditional probability, Boole's inequality, Markov's inequality, Chebychev's inequality, Bayes' theorem, - Banach space, (topological) dual space, bilinear form, inner product, Hilbert space, Cauchy-Schwarz inequality, orthogonal decomposition, orthogonal projection.

## Structure

The course, comprising 4+2 hours per week, is split into a lecture series (two lectures a 2h each week) and accompanying exercise classes (one class a 2h each week). An exercise sheet will be assigned every week for homework and the students are requested to present their solutions during the exercise classes.

## Area of Specialization

Analysis, Numerical Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

It is necessary to solve the provided exercise sheets and actively participate in the exercise classes. The final exam will be in form of an oral exam after the lecture period.

## List of Literature


- M. Mohri, A. Rostamizadeh and A. Talwalkar, Foundations of Machine Learning, MIT Press, 2. Edition, 2018
- K. Murphy, Probabilistic Machine Learning: An introduction, MIT Press, 2021
- S. Shalev-Shwartz and S. Ben-David, Understanding Machine Learning: From Theory to Algorithms, Cambridge University Press, 2014
- I. Goodfellow, Y. Bengio and A. Courville, Deep Learning, MIT Press, 2016

# Scientific Programming and Advanced Numerical Methods

## an introduction with case studies

Course Code: 03-M-SP-14

Prof. Dr. Stephan Frickenhaus & Prof. Dr. Alfred Schmidt

Contact: stephan.frickenhaus@awi.de, alfred.schmidt@uni-bremen.de

## Description

Research software development deserves a systematic approach to keep up with the demand for reproducible science and reuse of codes as a citeable scientific output. In the context of Open Science, sustainable research software is more and more estimated as vital component of research infrastructures. This course provides an introduction to the practice of scientific programming to a broader audience. The basis are advanced numerical methods and real world research codes that will be explored and executed on local programming environments - either on students laptops or on central compute nodes at University Bremen. Principles of code-management and code publication will be actively explored in small practical projects, open for students interests in bringing their own software projects. Some main "code use cases" are provided, based on Fortran and C programming language, and further projects are offered for R and C++ as well. Special emphasis is laid on performance optimization and two standard approaches of parallelization, i.e. loop parallelization and domain decomposition. Advanced numerical methods like domain decomposition, efficient solvers for large systems of equations, preconditioning, etc. will be presented and discussed. The course is useful for math students and interested participants from other fields (e.g. industrial math, numerics of PDEs, modeling seminar, material sciences - ProMat).

## Prerequisites

Your own laptop computer is needed and it will make your project work at home easier. We'd install a working programming environment on the basis of WindowsSubsystemLinux (WSL) or Cygwin, or enable access to the ZeTeM cluster via VPN. We use open Gnu-Software of programming language compilers.

## Structure

4 SWS on a weekly basis, practicals are in blocks; the course offers 9 EC. You will work with your laptops and access the computers at ZeTeM via VPN.

## Area of Specialization

Numerical Analysis, Industrial Mathematics

## Examination and Formalities

For successful participation we expect a project report or a "code talk" with theoretical basics and demonstration how code was adopted, tested and extended, including documentation, possibly towards publication.

# Selected topics in convex optimization

Course Code: 03-M-SP-35

Sebastian Banert

Contact: banert@uni-bremen.de

## Description

A convex optimisation problem means finding a minimiser of a convex function over a convex set. In other words, if you have two feasible points, you can take an average between two points, and this average will also be feasible ("over a convex set"), and the function value there will at most be the average of the two function values you started with (this is what "convex function" means). This rather innocuous looking property has huge consequences for the optimisation and is what makes problems algorithmically tractable. First of all, an algorithm can never be stuck in local optima that are globally suboptimal because convexity implies that every local optimum must automatically be global. Secondly, as we will see throughout the course, convexity is crucial for the numerical analysis of algorithms. We will discuss subgradients (convexity means that they exist), proximal points (convexity means that they are well-defined), stochastic algorithms (they are the foundation for training neural networks), and performance estimation (a powerful framework which describes the worst-case performance of an algorithm as a solution of a different convex optimisation problem). The course will give many examples of convex optimisation problems and will provide you will all necessary tools to implement and analyse algorithms to solve the algorithms that are discussed in the course.

## Prerequisites

Linear algebra and calculus in one and several variables are needed. For the programming exercises, familiarity with a programming language like Python/numpy, Julia, Octave or equivalent is assumed. Basic knowledge in functional analysis, convex analysis, stochastics, optimisation etc. can be helpful, but is not needed. The course will develop the theory in finite-dimensional spaces with inner products; results from convex analysis and probability theory will be stated without proof, but with hints to the literature.

## Structure

180 minutes of lectures (blackboard presentation), 90 minutes of exercises per week.

## Area of Specialization

Numerical Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

Oral exam (30 minutes), Studienleistung satisfied by solving the exercises and presenting the solutions. Details on the procedure will be given during the first week of the course.

## List of Literature

The lecture is not based on a single source. General resources for parts of the material are

- Heinz H. Bauschke, Patrick L. Combettes: Convex analysis and monotone operator theory in Hilbert spaces, 2nd ed., Springer, 2017. [http://link.springer.com/10.1007/978-3-319-48311-5] (http://link.springer.com/10.1007/978-3-319-48311-5)

- Ernest K. Ryu, Wotao Yin: Large-scale convex optimization, Cambridge University Press, 2022. Video lectures available. [https://large-scale-book.mathopt.com/] (https://large-scale-book.mathopt.com/)

- Adrien B. Taylor: Convex interpolation and performance estimation of first-order methods for convex optimisation. PhD thesis, UC Louvain, 2017. [https://dial.uclouvain.be/pr/boreal/object/boreal%3A182881/datastream/PDF_01/view](https://dial.uclouvain.be/pr/boreal/object/boreal%3A182881/datastream/PDF_01/view)

- Sebastian Banert: Large-scale convex optimisation, video lectures, 2021. [https://www.youtube.com/playlist?list=PLK8999LLfv8vABhiYsGq_gYCmrY0tpw4t] (https://www.youtube.com/playlist?list=PLK8999LLfv8vABhiYsGq_gYCmrY0tpw4t)

Pointers to specific topics and results will be given during the course.

# Semiparametric Models

Course Code: 03-M-SP-33

Prof. Dr. Werner Brannath

Contact: brannath@uni-bremen.de

## Description

Many statistical models are so called "parametric models", which are based on strong distributional assumptions, like e.g. normality and/or linearity. This permit to determine the distributions with a finite number of parameters. However, this assumption can severely limit the applicability of such models. In order to meet more general situations, non-parametric and semiparametric models have been suggested which provide more flexibility for a better model fit by utilizing infinite dimensional parameter spaces. A simple example for a non-parametric model is the distribution of a real random variable $Y$ which can always be represented by its distribution function $F$. The distribution function $F$ can viewed as an infinite dimensional parameter that is an element of the infinite dimensional space of all possible distribution functions $\mathcal{F}$ on $\mathbb{R}$. If $Y$ is known to have an expectation $\mu \in \mathbb{R}$, an alternative parametrization is given by $\mu$ and the distribution function $F_0$ of $Z = Y - \mu$, whereby the latter is an element of the infinite dimensional space $\mathcal{F}_0$ of all distribution functions with zero expectation. While the first model is non-parametric, the second with parameters $(\mu, F_0) \in \mathbb{R} \times \mathcal{F}_0$ corresponds to a semiparametric model, where the parameter has a finite component (here $\mu \in \mathbb{R}$) and an infinite component (here $F_0 \in \mathcal{F}_0$). Semiparametric models are particularly useful if the main interest lies in the parametric component (e.g. the expectation $\mu$) while the non-parametric component is only required to better capture the true distribution. This course will provide an introduction into the theory of semiparametric models. We will introduce and discuss the mathematical statistical theory for such models and will illustrate the utility of semiparametric models with a number of concrete models and data examples. Hence, the lecture and exercises will cover theoretical and practical aspects of semiparametric models. We will use the open statistical software R for the data applications.

## Prerequisites

Basic knowledge in mathematical statistics (e.g. from our Statistics I course), linear algebra and analysis I-III (e.g. banach spaces). Helpful (but not required) is also some knowledge about regression models (e.g. from our Statistics II course) and R.

## Structure

Lectures on Tuesday and Thursday between 8 and 10 am (90 Minutes each) plus excises on Friday between 2 and 4 pm. More details will be given in the first lecture.

## Area of Specialization

Statistics/Stochastics, Data Analysis

## Examination and Formalities

Solving and presenting exercises in the exercise course and a final oral exam on the topics covered in the lectures and exercises. More details will be given in the first lecture.

## List of Literature


- Bickel, P.J., Klaassen, C.A.J., Ritov, Y. and Wellner, J.A. (1993). Efficient and Adaptive Estimation for Semiparametric Models. Johns Hopkins University Press, Baltimore.
- van der Vaart, A.W. (1998). Asymptotic Statistics. Cambridge University Press.
- Vermeulen, K. (2011). Semiparametric Efficiency. Master thesis, University of Gent. https://libstore.ugent.be/fulltxt/RUG01/001/787/545/RUG01-001787545_2012_0001_AC.pdf

# Spectral Theory

Course Code: 03-M-SP-32

Dr. Hendrik Vogt

Contact: hendrik.vogt@uni-bremen.de

## Description

Topics of the lecture:

- Spectral theorem for compact operators
- The resolvent as a meromorphic functions with poles at the eigenvalues
- Jordan normal form
- Spectral theorem for self-adjoint operators
- Riesz–Markov representation theorem
- Fredholm operators, compact perturbations
- Functional calculus, spectral projections

## Prerequisites

This course is intended for Master students with a some knowledge of basic Functional Analysis. In addition, knowledge of results from Complex Analysis up to Cauchy's integral formula will be helpful. These prerequisites are not strictly necessary! The lectures will we adapted to your knowledge from previous lectures.

## Structure

This is a classical 4+2 course with two 2-hours lectures and one 2-hour exercise session per week.

## Analysis, Industrial Mathematics

## Examination and Formalities

There will be a homework sheet each week; students are supposed to present their solutions during the exercise sessions. The examination will be an oral exam in the semester break.

# Advanced Communication Analysis

Course Code: 03-M-AC-22

Prof. Dr. Anke Pohl

Contact: apohl@uni-bremen.de

## Description

In the Seminar Analysis we learn an advanced, modern topic in the area of analysis. The precise topic for Summer semester 2024 will be decided upon with the participants. Suggestions are welcome! The topic can be based on recent journal articles or textbook literature. This course can serve as a basis for master theses. Please sign in into the Stud.IP group early on if you are interested in this reading course in order to contribute to the discussion on the topic. You can deregister at any time.

## Prerequisites

Solid mathematical knowledge to the extent of a bachelor's degree in mathematics.

## Structure

Weekly presentations of material by participants. Check in Stud.IP for date and time of first meeting.

## Area of Specialization

Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

Exam: presentation (ca. 70 min) of a subtopic and written exposition. Both are graded, course grade is the mean of these two grades. Coursework: active participation in discussions.

## List of Literature

References will be provided via Stud.IP.

# Advanced Robust Control

Course Code: 03-M-AC-23

Dr. Chathura Wanigasekara

Contact: chathura@uni-bremen.de

## Description

In this course design of advanced robust controllers are discussed for nonlinear systems and linear multi-agent systems. Robust control is an approach to design controllers to deal with uncertainty. The aim is to achieve robust performance (or stability) in the presence of bounded modeling errors.

## Prerequisites

Basic knowledge of control systems; Basic knowledge of optimisation

## Structure

Weekly presentations of material by participants. Check in Stud.IP for date and time of first meeting.

## Area of Specialization

Numerical Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

Will be provided.

## List of Literature

- B. Francis, A course in $H_\infty$ control theory, Springer-Verlag, 1987.
- J. Doyle, B. Francis, A. Tannenbaum, Feedback Control Theory, Macmillan Publishing Company, 1990.
- S. Skogestad, I. Postlethwaite, Multivariable Feedback Control, Analysis and Design, John Wiley & Sons, 1996.
- K. Zhou, J.C. Doyle, K. Glover, Robust and Optimal Control, Prentice-Hall, 1996.

- G. E. Dullerud, F. Paganini, A Course in Robust Control, Springer-Verlag, 1999.
- S. P. Bhattacharya, H. Chapellat, L. H. Keel. Robust Control-The Parametric Approach, Prentice Hall, 2000.

# Advanced Numerical Methods for Partial Differential Equations

Course Code: 03-M-AC-19

Prof. Dr. Alfred Schmidt

Contact: alfred.schmidt@uni-bremen.de

## Description

Many models from applications lead to nonlinear partial differential equations or systems of partial differential equations. Their solution as well as aspects of optimization typically demand for numerical methods. In the summer term 2024 we will especially look at numerical methods for models in engineering applications from fluid dynamics and grinding processes, as well as methods for optimization with PDEs. Numerical aspects of thermo-mechanics or thermo-fluiddynamics, as well as multi-scale-models or week formulations of boundary conditions may be subject of seminar talks.

## Prerequisites

Advantageous will be a good knowledge of analysis and numerical methods, as well as some proficiency in numerical methods for partial differential equations, which is typically taught in the lectures of the same name.

## Structure

Successful conclusion of the seminar demands an oral presentation of about 60 minutes plus discussion and a written elaboration about the subject of the talk. A preliminary discussion of available subjects will be offered in the first semester week, but subjects can be assigned later, too. Just get in touch with the organizer.

## Area of Specialization

Numerical Analysis, Data Analysis, Industrial Mathematics

## Examination and Formalities

Successful conclusion of the seminar demands an oral presentation of about 60 minutes plus discussion and a written elaboration about the subject of the talk.

# Modeling Project (Part 1)

Course Code: 03-M-MP-1

Dr. Tobias Kluth

Contact: tkluth@math.uni-bremen.de

## Description

Over the course of two semesters, the participants of the modeling project work in teams on a project in which they are supposed to use the mathematical knowledge they have already acquired in applications outside of mathematics. The project partners can be industrial companies or research institutes. The range of topics is determined by the offers of the project partners. For example, the previous cooperation with partners included Alfred-Wegner-Institute, Bosch, Bruker Daltonics, German Aerospace Center, KUKA, Sikora, etc.

## Prerequisites

The modeling project is offered for students in the Master's program in Industrial Mathematics and Data Analysis. In limited exceptions, students in the Master's program in Mathematics can also participate.

## Structure

Regular meetings and presentations by the participants on their topics and the current status of their work.

## Examination and Formalities

The assessment will take place at the end of the modeling project (part 2) in February 2025 on the basis of these submissions:

- Internal mathematical presentation and public user-oriented presentation
- Written report (approx. 30 pages)
- Poster or comparable format, e.g. video, interactive software, demonstrator

# Reading Course Algebra

Course Code: 03-M-RC-ALG

Prof. Dr. Dmitry Feichtner-Kozlov

Contact: dfk@math.uni-bremen.de

## Description

Independent study of selected topics of the mathematical area algebra using monographs and research articles.
The goal of the course is to familiarize students with selected topics in the area specialization algebra via books, articles and other specialized literature. This will take place under the guidance of an independent teaching assistant in algebra and related areas (as well as geometry or topology).

## Structure

Beside your self-study, there will be regular meetings to discuss the in an informal or formal manner. Also written reports are mandatory and the course may include an introduction to in-depth fundamentals. This should ideally be used to familiarize the student with topics related to a Master's thesis.
You choose your supervisor; the coordinator, Prof. Dmitry Feichtner-Kozlov will be happy to advise you. You should first discuss the topic of the reading course with the supervisor. This person should then contact the coordinator and agree on the content.

## Area of Specialization

Algebra

## Examination and Formalities

Successful participation will be certified upon request at the end of the Reading Course by the coordinator in consultation with the supervisor.
Please also refer to the module description in the module handbook. Supervision by a university lecturer, or a research assistant from the ALTA Institute is professionally obvious.
All further achievements (typically a written paper and a longer presentation) will be agreed upon as part of the supervision.

# Reading Course Analysis

Course Code: 03-M-RC-ANA

Prof. Dr. Anke Pohl

Contact: apohl@uni-bremen.de

## Description

In the Reading Course Analysis we learn an advanced, modern topic in the area of analysis. The precise topic for Summer semester 2024 will be decided upon with the participants. Suggestions are welcome! The topic can be based on recent journal articles or textbook literature. The reading course can serve as a basis for master theses. Please sign in into the Stud.IP group early on if you are interested in this reading course in order to contribute to the discussion on the topic. You can deregister at any time.

## Prerequisites

Solid mathematical knowledge to the extent of a bachelor's degree in mathematics. Choice of material and level of discussion of background material will be adapted to the previous knowledge of the participants.

## Strucutre

Weekly assignments of reading material, weekly meetings for discussions and presentations of material by participants. Check in Stud.IP for date and time of first meeting.

## Area of Specialization

Analysis

## Examination and Formalities

Active participation (reading material, presentations and discussions), written exposition of selected material

## Literature

References will be provided via Stud.IP.

# Reading Course Numerical Analysis

Course Code: 03-M-RC-NUM

Lecturers of the ZeTeM

Contact: bueskens@uni-bremen.de, knauer@uni-bremen.de

## Description

Students study special topics of numerical analysis in this reading course. The aim is a self-study of selected topics on the basis of textbooks, scientific articles or other monographs. The course may also include an introduction into other associated topics or to special software (e.g. Alberta, WORHP). In addition, aspects of scientific work will be discussed, e.g. obtaining relevant literature, correct citation, or structure of a scientific article. All this is done under the supervision of a lecturer from the ZeTeM. In addition to the self-study, there will be regular meetings with the supervisor to discuss the topics in an informal or formal way and also written reports on a regular basis are mandatory. The topic will be discussed with the supervisor and, ideally, it is already into the direction of a future Master's thesis.

## Prerequisites

Basic knowledge from a mathematical Bachelor's degree, in particular from the modules Algebra, Analysis 1-2, Linear Algebra, Numerical Analysis 1, Numerical Analysis 2, and also programming skills can be beneficial.

## Structure

The lecture will be held in English.

## Area of Specialization

Numerical Analysis

## Examination and Formalities

Will be communicated during the lecture. Academic achievement(s): Yes For example: Regular and successful processing of exercises and active participation in the tutorial.

## Literature

Depending on the topic to be worked on and independent research for suitable specialized literature.

# Reading Course Statistics/Stochastics

Course Code: 03-M-RC-STS

Prof. Dr. Werner Brannath & Prof. Dr. Thorsten Dickhaus

Contact: brannath@uni-bremen.de

## Description

The aim of the reading course is to introduce the students to specific topics that may be relevant for the Master's thesis, using mainly original English-language literature (scientific articles and reference books). The participants are expected to work independently (with the advice of their supervisors) on the topic, give a lecture on it and prepare an term paper. Prof. Brannath and Prof. Dickhaus will announce topics for lectures in the first meeting and Stud.IP. If you are interested in topics of other lecturers (e.g. Marc Keßeböhmer, Vanessa Didelez, Iris Pigeot or Marvin Wright), please contact these lecturers directly, ideally before our first meeting. Students can also consider their own suggestions for topics, but they must also discuss these with one of the lecturers from Stochastics or Statistics (as potential Master's thesis supervisors) best before the first meeting. The assignment of the topics as well as the scheduling of all lectures will take place in the first meeting.

## Prerequisites

Subject-related prerequisites are basic knowledge of stochastics and statistics, as taught e.g. in the lectures "Stochastics" and "Basics of Mathematical Statistics" at the University of Bremen.

## Structure

The Reading Course Stochastics/Statistics will take place in the form of a seminar. Dates and topics will be determined in a preliminary meeting at the beginning of the semester. The day and time of this meeting will be announced via Stud.IP, latest a week before the semester starts. Registration at Stud.IP is therefore a necessary prerequisite for participation.

## Area of Specialization

Statistics/Stochastics

## Examination and Formalities

See module description.