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Software Engineering Practical

**Lecturer:** Prof. Atkinson  
**ECTS:** 5  
**Course Description:**  
This is the practical course accompanying Software Engineering I. It teaches students to apply their knowledge of the theory of software engineering by having them develop their own software system.  
The students will receive a set of requirements for a software system just as if they were working on a real industrial project. Their task is then to produce a complete software system including a working implementation, a design document, etc. based on the requirements. The students will develop their own solutions in small teams.  
Each team will have regular meetings to discuss their progress and assign specific tasks to each student in the team.  
The goal of this practical course is to gain a far deeper understanding of software engineering than is possible via studies of the theory alone.

Software Engineering I

**Lecturer:** Prof. Atkinson  
**ECTS:** 6  
**Course Description:**  
This course teaches students about engineering methods and tools for team-oriented development of non-trivial software systems. In particular:  
- Software development processes  
- System and requirements analysis  
- Application design and system architecture  
- Software quality  
- Validation, verification and testing  
- Maintenance  

The students learn about key technologies and processes of modern software engineering. After completion of the course they will be able to describe, design and develop complex software systems while accounting for requirements and risks common in industrial projects (e.g. quality, costs, deadlines, ...).
Selected Topics in IT-Security

**Lecturer:** Prof. Armknecht  
**ECTS:** 6  

**Course Description:**  
The large-scale deployment of Internet-based services and the open nature of the Internet come alongside with the increase of security threats against existing services. As the size of the global network grows, the incentives of attackers to abuse the operation of online applications also increase and their advantage in mounting successful attacks becomes considerable. These cyber-attacks often target the resources, availability, and operation of online services. In the recent years, a considerable number of online services such as Amazon, CNN, eBay, and Yahoo were hit by online attacks; the losses in revenues of Amazon and Yahoo were almost 1.1 million US dollars. With an increasing number of services relying on online resources, security becomes an essential component of every system. This course aims to increase the security awareness of students and offers them a basic understanding with respect to a variety of interesting topics. After this course, students will be able to (1) learn about symmetric and asymmetric encryption schemes, (2) classify and describe vulnerabilities and protection mechanisms of popular network protocols, web protocols, and software systems (2) analyze / reason about basic protection mechanisms for modern OSs, software and hardware systems.

**Content Description**  
This lecture covers the security of computer, software systems, and tamper resistant hardware. The course starts with a basic introduction on encryption functions, spanning both symmetric and asymmetric encryption techniques, IBE encryption and Zero-Knowledge proofs, and discusses reported side-channel attacks. The course then continues with a careful examination of wired and wireless network security issues, and web security threats and mechanisms. This part also extends to analysis of buffer overflows. Finally, the course also covers a set of selected security topics such as trusted computing and electronic voting.

**Topics:**  
- Encryption Schemes (Private Key vs. Public Key, Block cipher security)  
- IBE Encryption and Zero Knowledge Proofs  
- Side channel attacks  
- Network Security  
- Wireless Security  
- Web Security (SQL, X-Site Scripting)  
- Buffer Overflows  
- Malware & Botnets  
- Trusted computing  
- Electronic Voting
Data Mining

**Lecturer:** Prof. Paulheim  
**ECTS:** 6  
**Course Description:**  
The course provides an introduction to advanced data analysis techniques as a basis for analyzing business data and providing input for decision support systems. The course will cover the following topics:  
- Goals and Principles of Data Mining  
- Data Representation and Preprocessing  
- Clustering  
- Classification  
- Association Analysis  
- Text Mining  
- Systems and Applications (e.g. Retail, Finance, Web Analysis)

Learning outcomes and qualification goals:  
**Expertise:**  
Students will acquire basic knowledge of the techniques, opportunities and applications of data mining.

**Methodological competence:**  
- Successful participants will be able to identify opportunities for applying data mining in an enterprise environment, select and apply appropriate techniques, and interpret the results.  
- project organisation skills

**Personal competence:**  
- team work skills  
- presentation skills

Large-Scale Data Management

**Lecturer:** Prof. Gemulla  
**ECTS:** 6  
**Course Description:**  
This course introduces the fundamental concepts and computational paradigms of large-scale data management and Big Data. This includes methods for storing, updating, querying, and analyzing large dataset as well as for data-intensive
computing. The course covers concept, algorithms, and system issues; accompanying exercises provide hands-on experience. Topics include:

- Parallel and distributed databases
- MapReduce and its ecosystem
- NoSQL
- Stream processing
- Graph databases

Expertise:
Students will acquire knowledge about methods and systems for managing large datasets and data-intensive computing.

Methodological competence:
- Be able to judge, select, and use traditional or non-traditional data management systems for a given data management task
- Be able to solve computational problems involving large datasets

Personal competence:
- Study independently
- Presentation and writing skills

Multimedia Technology

Lecturer: Dr. Stephan Kopf
ECTS: 6
Course Description:
Aim of module:
1. What is multimedia?
   Motivation and fundamentals
2. Multimedia Compression Algorithms
   Lossless compression: Huffman Code, Lempel-Ziv Code, arithmetic coding;
   Still image compression: block truncation coding, DCT, JPEG, wavelet-based coding; Video compression: MPEG-1, MPEG-2, H.261, H.263, MPEG-4; Audio compression: PCM, MPEG-Audio, linear predictive coding
3. Multimedia Communication
   Quality of service: delay, jitter, loss and their implications; Network protocols for continuous media; Multicast protocols; Transport protocols for continuous media streams
4. Automatic Content Analysis
   Video content analysis: cut detection, motion detection; color histograms and edge change ratio; Applications in video indexing, genre recognition, video abstracting

Learning outcomes and qualification goals:
Expertise:
- Understand compression algorithms (lossless, lossy) for multimedia applications
• Understand communication problems for multimedia data streams (e.g., real-time capability, adaptive streaming with a high data rate, quality of service provisioning)
• Understand approaches to multimedia content analysis (e.g., color histograms, edge change ratio)
• Capability to judge and compare algorithms for multimedia processing

Methodological competence:
• Can design and implement algorithms for multimedia processing
• Can recommend multimedia components for specific business applications, e.g., for video processing

Personal competence:
• Can study independently
• Works well in a team
• Can mediate between computer scientists and business people

Information Retrieval and Web Search

Lecturer: Prof. Ponzetto
ECTS: 6
Course Description:
Given the vastness and richness of the Web, users need high-performing, scalable and efficient methods to access its wealth of information and satisfy their information needs. As such, being able to search and effectively retrieve relevant pieces of information from large text collections is a crucial task for the majority (if practically not all) of Web applications. In this course we will explore a variety of basic and advanced techniques for text-based information retrieval and Web search. Covered topics will include:

• Efficient text indexing;
• Boolean and vector space retrieval models;
• Evaluation of retrieval systems;
• Probabilistic Information Retrieval;
• Text classification and clustering;
• Web search, crawling and link-based algorithms.

Coursework will include homework assignments, a term project and a final exam. Homework assignments are meant to introduce the students to the problems that will be covered in the final exam at the end of the course. In addition, students are expected to successfully complete a term project in teams of 2-4 people. The projects will focus on a variety of IR problems covered in class. Project deliverables include both software (i.e., code and documentation) and a short report explaining the work.
performed and its evaluation.

Expertise:
Students will acquire knowledge of fundamental techniques of Information Retrieval and Web Search, including standard retrieval models, evaluation of information retrieval systems, text classification and clustering, as well as web search topics such as crawling and link-based algorithms.

Methodological competence:
Successful participants will be able to understand state-of-the-art methods for Information Retrieval and Web search, as well as being able to select, apply and evaluate the most appropriate techniques for a variety of different search scenarios.

Personal competence:
- presentation skills;
- team work skills.

Web Mining

Lecturer: Prof. Bizer
ECTS: 6
Course Description:
The textual content as well as the structured data which is accessible on the Web has an enormous potential for being mined to derive knowledge about nearly any aspect of human life. The course covers advanced data mining techniques for extracting knowledge from Web content as a basis for business decisions and applications. The course will cover the following topics:
- Goals and Principles of Web Mining
- Gathering and Preprocessing Web Data
- Social Network Analysis
- Opinion Mining and Sentiment Analysis
- Web Usage Mining
- Executing Large Scale Web Mining Tasks

Learning outcomes and qualification goals:
Expertise:
Students will acquire knowledge of the techniques, opportunities and applications of Web mining.

Methodological competence:
- Successful participants will be able to identify opportunities for mining knowledge from Web content, select and apply appropriate techniques and interpret the results.
The course consists of a lecture together with accompanying practical exercises as well as student team projects. In the exercises the participants will gather initial expertise in applying state of the art web mining tools. In the team projects, which take place in the last third of the term, the students realize more sophisticated Web mining projects of personal choice and report about the results of their projects in the form of a written report as well as an oral presentation.
Knowledge Management: Principles and Technologies

**Lecturer:** Prof. Völker  
**ECTS:** 6

**Course Description:**  
The participants of this course learn about the challenges and opportunities for IT support in knowledge management. They will become acquaint with the technological foundations of knowledge management systems, including computational methods for searching, extracting, distributing and using knowledge in an organization. During this course, the students will acquire the competence for effectively using computational methods for knowledge acquisition, representation and maintenance. By collaborating on practical and theoretical exercises the participants of this course learn how to effectively work in teams. They improve upon their presentation skills by presenting their solutions in the tutorials.

**Aim of module:**  
- Information Retrieval  
- Text Mining and Information Extraction  
- Knowledge Repositories  
- Social Network Analysis  
- Crowdsourcing

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Enterprise Architecture Modeling

**Lecturer:** Prof. Atkinson  
**ECTS:** 6

**Course Description:**  
Enterprise architectures describe the organizing logic for business processes and IT infrastructure reflecting the integration and standardization requirements of a company's operating model. The operating model is the desired state of business process integration and business process standardization for delivering goods and services to customers. In this course students will become familiar with state-of-the-art enterprise modeling approaches and tools such as Zachmann, Archimate, TOGAF and RM-ODP.

**Learning outcomes and qualification goals:**  
After taking this course students will be familiar with the main ingredients of enterprise architectures and state-of-the-art tools/approaches for designing and modeling them.

**Methodological competence:**  
Students will have the expertise needed to participate in the development of
enterprise architecture modeling teams and will be familiar with common problems and pitfalls.

Personal competence:
With the acquired skills and know-how, students will be able to play a key role in enterprise architecture development, analysis and implementation.

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### Hot Topics in Machine Learning

**Lecturer:** Prof. Gemulla  
**ECTS:** 6

**Course Description:**  
Machine Learning is about designing algorithms that are able to make predictions about data or extract knowledge from data. The aim of this module is to study algorithms, underlying concepts, and theoretic principles that allow for algorithms to automatically learn how to make predictions. The course focuses on selected "hot topics" and their applications, which include:

- Basics of machine learning and probability theory
- Probabilistic graphical models
- Inference and parameter estimation
- Neural networks

**Expertise:**  
Deep understanding of algorithms and underlying concepts of machine learning

**Methodological competence:**  
- Being able to apply machine learning techniques and systems for a given problem
- Being able to model and implement new machine learning techniques
**Spring 2015**
**Mathematics**
**Bachelor Courses**

<table>
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<tr>
<th>Dynamical Systems</th>
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<tbody>
<tr>
<td><strong>Lecturer:</strong> Prof. Boshi. Li Chen</td>
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<tr>
<td><strong>ECTS:</strong></td>
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<tr>
<td><strong>Course Description:</strong></td>
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<tr>
<td>• Ordinary differential equations</td>
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**Advanced Mathematical Finance**

<table>
<thead>
<tr>
<th>Lecturer:</th>
<th>Prof. Dr. Alexander Schied</th>
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<tbody>
<tr>
<td><strong>ECTS:</strong></td>
<td>9</td>
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<tr>
<td><strong>Course Description:</strong></td>
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<tr>
<td>• basics of continuous-time arbitrage theory</td>
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<td>• martingale representation property and market completeness</td>
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<tr>
<td>• stochastic volatility models</td>
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<tr>
<td>• term structure theory for volatility and interest rates</td>
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<tr>
<td>• optimal investments and basics of stochastic optimal control; in particular verification arguments for Hamilton-Jacobi-Bellman equations</td>
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<tr>
<td>• optimal order execution in illiquid markets</td>
<td></td>
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<tr>
<td>• special topics in continuous-time finance</td>
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</tbody>
</table>

Learning outcomes and qualification goals:

**Expertise:**
- Advanced knowledge of the most important objects and results in continuous-time finance

**Methodological competence:**
- Several competences using methods of Stochastic Analysis.

**Personal competence:**
- Deeper understanding of complex modelling in finance
Hyperbolic conservation laws

Lecturer: Prof. Boshi. Prof. Chen
ECTS: 6

Course Description:
Hyperbolic conservation law has many applications (traffic flows, fluid dynamics, biology...), there are also many beautiful theories in this subject. In this course, we will discuss the typical problems in this field.

- One dimension conservation law, the Burgers’ equation
- General conservation law system

Application on a nozzle flows, irrotational and rotational flows Learning outcomes and qualification goals:

Expertise:
- Singularity formulation,
- Rankine-Hugoniot condition,
- entropy condition,
- Riemann problem, wave interaction and large time behavior.

Methodological competence:
- $L^1$ contraction, (BF1)
- Glimm Scheme (BF1, BO2)
- Compensated compactness (BF1)

Personal competence:
- Working in groups

Partial Differential Equations II

Lecturer: Prof. Dr. Martin Schmidt
ECTS: 8

Course Description:
This course is held in English when demanded.
# Fall 2015
## Informatics
### Bachelor Courses

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<td><strong>Lecturer:</strong> Dr. Stephan Kopf</td>
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<tr>
<td><strong>ECTS:</strong> 6</td>
</tr>
<tr>
<td><strong>Course Description:</strong></td>
</tr>
<tr>
<td>An Introduction to Computer Network Technology</td>
</tr>
</tbody>
</table>

1. **Introduction**
   - Motivation for networks, history; protocol hierarchies; standardization bodies; the ISO Reference Model for Open Systems Interconnection

2. **The Physical Layer**
   - Definition; mechanical/electrical/functional properties of the physical layer; transmission techniques; modulation techniques; bit encoding; physical media; example: DSL

3. **Data Link Layer**
   - Transmission errors: causes, detection, correction; error detecting and error correcting codes; multiplexing; sequence numbers and acknowledgments; flow control; example: PPP

4. **Local Area Networks**
   - Topologies for LANs; medium access control: ALOHA, slotted ALOHA, CSMA/CD (Ethernet); hubs, switches and bridges

5. **Wide Area Networks and Routing**
   - Packet switching vs. circuit switching; virtual circuits vs. datagrams; addressing in WANs; routing algorithms for point-to-point traffic; example: IPv4

6. **Transport Layer**
   - Purpose of the transport layer; transport protocols in the Internet: UDP; TCP, congestion control in TCP;

7. **Application Layer**
   - smtp for electronic mail; ftp for file transfer; nfs for remote file access; telnet for remote login; http for Web access

8. **The Domain Name System**
   - DNS architecture, DNS protocols
**Development and Management of Information Systems**

**Lecturer:** Prof. Dr. Alexander Mädche  
**ECTS:** 6  
**Course Description:**
During the last decades we witnessed a growing importance of Information Systems (IS) in the business world along with faster and faster innovation cycles. A case in point is the growing IS-related expenditure of corporations, forecasted to total EUR 2.63 trillion in 2012 – a 4.7% growth over 2011 (Gartner 2013). Ranging from the enrichment of routine working tasks (i.e., employee portals to integrate disparate applications, data, and processes (Daniel and White 2005)) to the e-enabled integration of entire business ecosystems (e.g., platform-based integration of supply chains (e.g., Kroenke 2010)), IS have become a vital backbone of businesses. Consequently, the ability to use IS in a way supporting the overall value proposition of a corporation has become a central success determinant for many firms. Accordingly, the “Development and Management of Information Systems” course is designed to introduce students to the nature, role, and potentials of IS in corporations and enable them to serve as a meaningful interface between technology and business. Once filling this role in a business context, the future IS professionals are likely to be facing two major trends: the increasing industrialization of IS (Brenner et al. 2007; Daberkow and Radtke 2008; Walter et al. 2007) and a shift towards service-orientation in IT organizations and processes (Hochstein et al. 2005; Roewekamp 2007). This brings about challenges such as, among others, managing the trade-off between efficient execution and effective offering or recognizing and mitigating conflicting expectations and goals among the many entities (i.e., software producers, consultants, corporate users, customers) and roles (i.e., business professionals, technical staff, corporate management) involved in an IS.

**Integrated Information Systems (Wifo)**

**Lecturer:** Prof. Dr. Thomas Kude  
**ECTS:** 6  
**Course Description:**
This course first outlines the basics of data and business process modelling based on wide-spread approaches such as entity relationship diagrams, event-driven process chains (EPC), and business process model and notation (BPMN). The remainder of the course then focuses on the use and purpose of integrated information systems across different functional areas in industrial companies. Finally, basics of management
support systems such as business intelligence systems are addressed.

- Business Process Modelling
- Application Systems in
  - Research and Development
  - Marketing and Sales
  - Procurement and Warehousing
  - Production
  - Shipping and Customer Service
  - Finance, Accounting, HR
- Planning and Control Systems

Informatics
Master Courses

Advanced Software Engineering

**Lecturer:** Prof. Atkinson  
**ECTS:** 6  
**Course Description:**  
The course provides an introduction to advanced data analysis techniques as a basis for analyzing business data and providing input for decision support systems. The course will cover the following topics:

- Goals and Principles of Data Mining
- Data Representation and Preprocessing
- Clustering
- Classification
- Association Analysis
- Text Mining
- Systems and Applications (e.g. Retail, Finance, Web Analysis)

Data Mining

**Lecturer:** Prof. Paulheim  
**ECTS:** 6  
**Course Description:**  
The course deals with the model-based specification of software systems and components as well as their verification, validation and quality assurance. The emphasis is
on view-based specification methods that use multiple views, expressed in multiple languages, to describe orthogonal aspects of software systems/components. Key examples include structural views represented using class diagrams, operational views expressed using constraint languages and behavioural views expressed using state diagrams. An important focus of the course is the use of these views to define tests and extra-functional properties.

### Decision Support

**Lecturer:** Prof. Stuckenschmidt  
**ECTS:** 6  
**Course Description:**  
The course provides an introduction to decision support techniques as a basis for the design of decision support systems. The course will cover the following topics:

- Decision Theory  
- Decision- and Business Rules  
- Planning Methods and Algorithms  
- Probabilistic Graphical Models  
- Game Theory and Mechanism Design

### Model Driven Development

**Lecturer:** Prof. Atkinson  
**ECTS:** 6  
**Course Description:**  
The course focuses on the principles, practices and tools involved in advanced model-driven development. This includes established modelling standard languages (e.g. UML, ATL, OCL . . .) and modelling infrastructures (e.g. MOF, EMF, etc.) as well as leading edge, state-of-the-art modelling technologies (e.g. LML, PLM . . .). Key topics addressed include –

- Multi-level modeling  
- Meta-modeling  
- Ontology engineering versus model engineering  
- Model transformations  
- Domain specific language definition and use  
- Model creation and evolution best practices
- Model-driven software development
- Model checking and ontology validation

### Semantic Web Technologies

**Lecturer:** Prof. Völker  
**ECTS:** 6  
**Course Description:**  
The participants of this course learn about principles and applications of Semantic Web standards. They become familiar with their technical foundations such as representation and query languages, or logical inference. After taking this course, the students will be aware of the problems and benefits of semantic technologies in the context of tasks such as knowledge management, information search and data integration, and they will be capable of judging the applicability of these technologies for addressing practical challenges.

The participants learn how to design and implement Semantic Web applications. They are able to use standardized modeling languages for building knowledge representations, and to query these models by means of languages such as SPARQL. By jointly building a semantic web application, the students learn how to effectively work in teams. They improve upon their presentation skills by showing the outcomes of their projects to the other participants of the course.

### Text Analytics

**Lecturer:** Prof. Ponzetto  
**ECTS:** 6  
**Course Description:**  
In the digital age, techniques to automatically process textual content have become ubiquitous. Given the breakneck speed at which people produce and consume textual content online – e.g., on micro-blogging and other collaborative Web platforms like wikis, forums, etc. – there is an ever-increasing need for systems that automatically understand human language, answer natural language questions, translate text, and so on. This class will provide a complete introduction to state-of-the-art principles and methods of Natural Language Processing (NLP). The main focus will be on statistical techniques, and their application to a wide variety of problems. This is because statistics and NLP are nowadays highly intertwined, since many NLP problems can be
formulated as problems of statistical inference, and statistical methods, in turn, represent de-facto the standard way to solve many, if not the majority, of NLP problems.

Covered topics will include:

- Words
  - Language Modeling
  - Part-Of-Speech Tagging

- Syntax
  - Statistical Parsing

- Semantics and pragmatics
  - Computational Lexical Semantics
  - Computational Discourse

- Applications
  - Topic Modeling
  - Information Extraction
  - Question Answering and Summarization
  - Statistical Alignment and Machine Translation

Coursework will include homework assignments and a final exam. Homework assignments are meant to introduce the students to the problems that will be covered in the final exam at the end of the course.

---

**Web Data Integration**

**Lecturer:** Prof. Bizer  
**ECTS:** 6

**Course Description:**

The Web is developing from a medium for publishing textual documents into a medium for sharing structured data. In the course, students will learn how to integrate and cleanse data from this global data space for the later usage of the data within business applications. The course will cover the following topics:

- Heterogeneity and Distributedness
- The Data Integration Process
- Web Data Formats
- Schema Matching and Data Translation
- Identity Resolution
- Data Quality Assessment
- Data Fusion

Students will be able to identify opportunities for employing Web data in business applications and will learn to select and apply appropriate techniques for integrating...
and cleansing Web data.

## Data Mining and Matrices

**Lecturer:** Prof. Dr. Rainer Gemulla  
**ECTS:** 6  
**Course Description:**
Many data mining tasks operate on dyadic data, i.e., data involving two types of entities (e.g., users and products, objects and attributes, or points and coordinates); such data can be naturally represented in terms of a matrix. Matrix decompositions, with which we (approximately) represent the data matrix as a product of two (or more) factor matrices, can be used to perform many common data mining tasks. In this lecture, we explore the use of matrix decompositions for denoising, discovery of latent structure, and visualization, among others. We cover data mining tasks such as prediction, clustering and pattern mining, and application areas such as recommender systems and topic modelling.

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### Fall 2015  
**Mathematics**  
**Bachelor Courses**

## Continuous-time Finance

**Lecturer:** Prof. Schied  
**ECTS:** 6  
**Course Description:**
In this course we develop the theory of modeling financial asset prices and corresponding trading strategies in continuous time. Applications include the pricing and hedging of financial derivatives and the construction of optimal investment strategies. In particular we will derive the celebrated formulas of Bachelier and of Black, Scholes, and Merton.

Our approach will differ from the usual approach found in most textbooks in that it will be based on a strictly pathwise version of Itô calculus. Thus we can avoid the technically demanding theory of stochastic integration. As a consequence, prior knowledge in Probability Theory is not essential (although it may be helpful). Very good skills in Analysis I & II are required.
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<tr>
<th>Course</th>
<th>Lecturer</th>
<th>ECTS</th>
<th>Course Description</th>
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<tbody>
<tr>
<td>Functional Analysis</td>
<td>PD Dr. Li Chen</td>
<td>8</td>
<td>This is a Bachelor course. The following contents will be covered: linear spaces; linear maps; the Hahn-Banach theorem; applications of the Hahn-Banach theorem; normed linear spaces; Hilbert space; duals of normed linear spaces; weak convergence; the weak and weak* topologies; locally convex topologies and the Krein-Milman theorem; Bounded linear maps; Banach algebras and their elementary spectral theory; Examples of operators and their spectra.</td>
</tr>
<tr>
<td>Seminar on Application of Mathematical Analysis</td>
<td>PD Dr. Li Chen</td>
<td>3</td>
<td>In this reading seminar, some mathematical models in population dynamics will be introduced. Moreover, the corresponding results such as singular limits and the long time behavior of the solutions will be obtained by mathematical analysis.</td>
</tr>
<tr>
<td>Game Theory</td>
<td>Prof. Dr. C. Hertling</td>
<td>5</td>
<td>Basics of game theory, games in normal form, Nash equilibria, zero sum games, mixed extensions of finite games, extensive games (with or without chance, with perfect information), subgame perfect games, repeated games, cooperative games, Shapley value, in form of exercises applications in economics.</td>
</tr>
<tr>
<td>Introduction to Probability Theory</td>
<td>Prof. Dr. Jürgen Potthoff</td>
<td>9</td>
<td>The course will be held in English if demanded.</td>
</tr>
<tr>
<td>Introduction to Mathematical Statistics</td>
<td>PD Dr. Frank Zeilfelder</td>
<td>8</td>
<td>This course is held in English when demanded.</td>
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</table>
Spline Theory

**Lecturer**: Prof. Dr. Martin Schlather  
**ECTS**: 3  
**Course Description**:  
This course is held in English when demanded.

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Mathematics  
Master Courses

**Introduction of Partial Differential Equations**

**Lecturer**: Prof. Chen  
**ECTS**: 8  
**Course Description**:  
This is an introduction course to PDEs. It includes linear transport equation, wave equation, heat equation and Poisson equation. Derivation of the solution formula by using characteristic method, separation of variable, Fourier transform are given. Classical tools such as maximum principle and energy estimates are introduced in order to get uniqueness and stability of the solutions.  
- Introduction and setting of the boundary value problem  
- Wave equation  
- Poisson equation  
- Heat equation  
- Energy methods  
- Maximum principle  

Learning outcome:  
- Linear partial differential equations (BK1)  
- D’Alembert formula (BK1, BO3)  
- Fundamental solutions (BK1, BO3)  
- Green’s functions (BK1, BO3)  
- Heat kernel (BK1, BO3)  
- Existence, uniqueness and stability (BK1, BO2)

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**2nd Order Parabolic Differential Equations**

**Lecturer**: Prof. boshi. Li Chen  
**ECTS**: 8  
**Course Description**:  
Second order parabolic differential equations are basic models in biomath, physics and financial math. In this course, we will introduce useful inequalities, basic techniques and Sobolev spaces at first. $L^2$ theory of linear equations and the unique existence of
classical solution will be studied. Also, De Giorgi interation and Moser interation and fix point theory will be discussed.

<table>
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<th>Asymptotic Analysis</th>
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<tr>
<td><strong>Lecturer:</strong> Dr. Wang</td>
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<tr>
<td><strong>ECTS:</strong> 6</td>
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<tr>
<td><strong>Course Description:</strong></td>
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<tr>
<td>Asymptotic analysis is to describe the behavior of a certain function near its limit. This method is widely used in many scientific fields, such as computer science and physics. In this course, we will focus on the topic of asymptotic approximations. We will start with the fundamental ideas underlying asymptotic approximations, and then we will demonstrate how to use this method to find approximate solutions for problems, including algebraic equations, ordinary differential equations and even partial differential equations arising from physical water waves, sound propagation, and aerodynamics of airplanes. Furthermore, we will also discuss how to use the matched asymptotic expansions to analyze problems with layers, and examine the stability.</td>
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<th>Optimal Control</th>
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<td><strong>Lecturer:</strong> Prof. Dr. Simone Göttlich</td>
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<td><strong>ECTS:</strong> 8</td>
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<td><strong>Course Description:</strong></td>
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<td>This lecture is devoted to the mathematical theory of optimal control. The historical evolution of subject is traced from early calculus of variations results to modern optimal control theory which is based on two key developments: the maximum principle and the principle of dynamic programming. The aim is to give sufficient instruments to afford optimal control problems arising from different application contexts. Special attention is dedicated to linear-quadratic optimal control problems and numerical methods used for solving them are discussed.</td>
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<table>
<thead>
<tr>
<th>Seminar on Diffusion Equations</th>
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<tr>
<td><strong>Lecturer:</strong> PD Dr. Li Chen</td>
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<tr>
<td><strong>ECTS:</strong> 3</td>
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<td><strong>Course Description:</strong></td>
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<tr>
<td>Second order parabolic partial differential equations, or diffusion type equations, are widely used in applied sciences. This student reading seminar will focus on a specific newly developed method for diffusion type equations, i.e. the entropy-entropy dissipation methods. This method is helpful for both the existence of weak solutions and the study of the qualitative behavior of the solutions.</td>
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<table>
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<tr>
<th>Seminar on Kinetic Models</th>
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<tr>
<td>22</td>
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</table>
## Lecturer: PD Dr. Li Chen  
**ECTS:** 3  
**Course Description:**  
The Vlasov equations are the most frequently used kinetic equations in statistical mechanics. In the last decades, this type of equations were widely used in many applied sciences, like group behavior of particles in biology, opinion formation and wealth distribution in social sciences. In this seminar, we will read the related materials on the rigorous derivation of kinetic equations from many particle systems. At the same time, the corresponding mathematical tools (such as Wasserstein distance) will be introduced.

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## Scientific Visualization  
**Lecturer:** Prof. Dr. Wolfgang Seiler  
**ECTS:** 8  
**Literature:**  
**Course Description:**  
The course will be held in English if demanded.

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## Computational Stochastic Differential Equations  
**Lecturer:** Prof. Dr. Andreas Neuenkirch  
**ECTS:** 6  
**Course Description:**  
The course will be held in English when demanded.

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## Research Seminar: Applied Analysis  
**Lecturer:** Prof. boshi. Li Chen  
**ECTS:** 3  
**Course Description:**  
This research seminar on applied analysis intends for the applied analysis group to read together the recent scientific works and report our ongoing new works. Please check details on our webpage to get updated schedule. Everyone who is interested in this topic is welcome to join us.