Handbook of Modules
for the
Master Study Programme Data Science
(Terms of study 2019/2020)
— preliminary version —
updated 12 April 2021

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Overview of modules

Compulsory Courses

<table>
<thead>
<tr>
<th>No.</th>
<th>MODULE NAME</th>
<th>Lectures/courses</th>
<th>ECTS points</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD 1</td>
<td>ADVANCED STATISTICAL LEARNING</td>
<td>Advanced Statistical Learning</td>
<td>9</td>
</tr>
<tr>
<td>MD 2</td>
<td>STATISTICAL THEORY</td>
<td>Statistical Theory</td>
<td>9</td>
</tr>
<tr>
<td>MD 3</td>
<td>DATA SCIENCE IN PRACTICE</td>
<td>Programming course</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Data Science in Context</td>
<td>3</td>
</tr>
<tr>
<td>MD 4</td>
<td>PROJECT WORK</td>
<td>Case Studies / External Internship</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Seminar</td>
<td>4</td>
</tr>
<tr>
<td>MD 5</td>
<td>BIG DATA</td>
<td>Big Data Analytics</td>
<td>9</td>
</tr>
<tr>
<td>MD 6</td>
<td>MASTER THESIS</td>
<td>Master Thesis</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advanced Seminar</td>
<td>3</td>
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Elective courses
(to choose modules with a total of 45 ECTS points)

<table>
<thead>
<tr>
<th>CATALOGUE OF MODULES</th>
<th>No.</th>
<th>Lectures/courses</th>
<th>ECTS points</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>METHODS</td>
<td>MD E1-1</td>
<td>Time Series Analysis</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>MD E1-2</td>
<td>Survival Analysis</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>MD E1-3</td>
<td>Bootstrapping</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>MD E1-4</td>
<td>Stichprobenverfahren</td>
<td>5</td>
<td>German</td>
</tr>
<tr>
<td></td>
<td>MD E1-5</td>
<td>Nonparametric Methods</td>
<td>4,5</td>
<td>English or German</td>
</tr>
<tr>
<td></td>
<td>MD E1-6</td>
<td>Robust Methods</td>
<td>4,5</td>
<td>English or German</td>
</tr>
<tr>
<td></td>
<td>MD E1-7</td>
<td>Optimization</td>
<td>5</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>MD E1-8</td>
<td>Numerical Solution of Differential Equations</td>
<td>5</td>
<td>English</td>
</tr>
<tr>
<td></td>
<td>MD E1-9</td>
<td>Generalized Linear Models</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td>Further modules from other study programmes</td>
<td></td>
<td></td>
<td></td>
<td>English or German</td>
</tr>
<tr>
<td>Other modules upon request</td>
<td></td>
<td></td>
<td></td>
<td>English or German</td>
</tr>
</tbody>
</table>

APPLICATIONS
(to choose modules with a total of at least 16 ECTS points)

<table>
<thead>
<tr>
<th>No.</th>
<th>Lectures/courses</th>
<th>ECTS points</th>
<th>Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD E2-1</td>
<td>Bioinformatics</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td>MD E2-2</td>
<td>Toxicology</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td>MD E2-3</td>
<td>Econometrics</td>
<td>9</td>
<td>English</td>
</tr>
<tr>
<td>MD E2-4</td>
<td>Econometrics of treatment effects and policy evaluation</td>
<td>4,5</td>
<td>English</td>
</tr>
<tr>
<td>MD E2-5</td>
<td>Natürlichsprachige Systeme</td>
<td>7</td>
<td>German</td>
</tr>
<tr>
<td>MD E2-6</td>
<td>Control Theory and Applications</td>
<td>7</td>
<td>English</td>
</tr>
<tr>
<td>No.</td>
<td>MODULE NAME</td>
<td>Lectures/courses</td>
<td>ECTS points</td>
</tr>
<tr>
<td>-------</td>
<td>--------------------------------------</td>
<td>-------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>MD Req1</td>
<td>ADVANCED MATHEMATICS</td>
<td>Advanced Engineering Mathematics</td>
<td>7</td>
</tr>
<tr>
<td>MD Req2</td>
<td>DATA STRUCTURES AND PROGRAMMING</td>
<td>Reading Course Data Structures and Programming</td>
<td>10</td>
</tr>
<tr>
<td>MD Req3</td>
<td>INFORMATION SYSTEMS</td>
<td>Reading Course Information Systems</td>
<td>5</td>
</tr>
<tr>
<td>MD Req4</td>
<td>PROBABILITY</td>
<td>Reading Course Probability</td>
<td>5</td>
</tr>
<tr>
<td>MD Req5</td>
<td>INFERENCE</td>
<td>Reading Course Inference</td>
<td>5</td>
</tr>
<tr>
<td>MD Req6</td>
<td>LINEAR MODELS</td>
<td>Reading Course Linear Models</td>
<td>5</td>
</tr>
<tr>
<td>MD Req7</td>
<td>INTRODUCTORY CASE STUDIES</td>
<td>Introductory Case Studies</td>
<td>5</td>
</tr>
</tbody>
</table>
Notes

- Elective courses can be in English or German (see terms of study, § 6 (6)).
- For courses with a written exam according to this handbook, there have to be two examination dates during the semester, generally one of them towards the end of the free period. Students not having passed or participated in the first date may participate in the second. If the examination is not passed at the second date, there is no right to a further attempt during the same semester, even if the student has not written the exam at the first regular date.
- Course type abbreviations:
  - L: Lecture
  - T: Tutorial
  - S: Seminar
  - P: Practical course

Preface on dissemination of skills

Understanding of the methodology of mathematical statistics cannot be acquired by simple memorising, but solely by exercises and application to practical questions and problems. This is usually done in tutorials accompanying all lectures. Therefore, they are a central part of the education.

Apart from understanding of the lectures’ contents, the accompanying tutorials impart strategies of learning: the students recognise the application of methods to practical questions as the easiest way of understanding. Writing out answers and solutions to exercises improves the ability to formulate propositions of mathematical statistics and the general capability of expression.

Application to real data is only possible by means of software. Therefore, after basic training in earlier phases of study, computational application of studied methods is required in the courses. Self-discipline and time management are trained by periodic and strict deadlines for finishing exercises. Motivation is increased by feedback on corrected exercises, since the students can judge their understanding of the subjects worked on. Therefore, it is an important part of the education to value and reward the students’ efforts in doing exercises.

Various examination modes are provided in the regulations. In particular, credit points may be obtained by the exercises mentioned above and by oral presentations. Communication skills and the ability to describe issues of mathematical statistics and data science are trained by oral exams. Written exams require the methods’ practical application.

Perhaps the most important soft skills in statistics and data analysis are communication and teamworking skills. Expedient data analysis and evaluation can only be achieved if all aspects of the data and problems are openly discussed between all the participants. The department of Statistics encourages these abilities by instructions to teamwork in various ways and by special tutorials held by fellow students.

A semester abroad also serves to develop such general, interdisciplinary skills. Students are encouraged to take some courses at a foreign partner university. In particular, the 3rd semester is suitable in this regard. Such international exchanges are for example supported by the ERASMUS programme (https://www.statistik.tu-dortmund.de/erasmus_en.html).
## Recommended course of study

### Starting in winter semester

**blue**: courses at the Faculty of Statistics; **green**: Faculty of Computer Science; **brown**: (joint) courses of these or other faculties

<table>
<thead>
<tr>
<th>1st semester</th>
<th>2nd semester</th>
<th>3rd semester</th>
<th>4th semester</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module MD 5:</strong>&lt;br&gt;Big Data</td>
<td><strong>Module MD 4:</strong>&lt;br&gt;Project Work</td>
<td><strong>Seminar</strong> (25); 4 ECTS; Graded partial work</td>
<td><strong>Module MD 6:</strong>&lt;br&gt;Master Thesis&lt;br&gt;Prerequisites: Modules MD 1 and MD 4&lt;br&gt;30 ECTS; Course achievement: Advanced Seminar („Oberseminar“); Graded module exam: Master Thesis</td>
</tr>
<tr>
<td>Big Data Analytics (4+2); 9 ECTS; Graded module exam</td>
<td>Case Studies (4P) or External Internship; 8 ECTS; Graded partial work</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module MD 2:</strong>&lt;br&gt;Statistical Theory</td>
<td><strong>Module MD 1:</strong>&lt;br&gt;Advanced Statistical Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistical Theory (4+2); 9 ECTS; Graded module exam</td>
<td>Advanced Statistical Learning (4+2); 9 ECTS; Graded module exam</td>
<td>Graded module exams or accumulated graded exams (at least 24 ECTS in total)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective courses: Methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module MD 3:</strong>&lt;br&gt;Data Science in Practice</td>
<td>Elective modules from catalogue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programming course (2 to 4 P); 3 ECTS; Data Science In Context (2); 3 ECTS; Accumulated graded exams</td>
<td></td>
<td>(In the entire elective area — Methods and Applications — modules with a total of 45 ECTS are to be chosen.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective courses: Applications</td>
<td>Graded module exams or accumulated graded exams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Elective modules from catalogue</td>
<td>(at least 16 ECTS in total)</td>
<td></td>
</tr>
<tr>
<td>Total: 30 ECTS</td>
<td>Total: 30 ECTS</td>
<td>Total: 30 ECTS</td>
<td>Total: 30 ECTS</td>
</tr>
</tbody>
</table>
Starting in summer semester

blue: courses at the Faculty of Statistics; green: Faculty of Computer Science; brown: (joint) courses of these or other faculties

<table>
<thead>
<tr>
<th>1st semester</th>
<th>2nd semester</th>
<th>3rd semester</th>
<th>4th semester</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module MD 1:</strong> Advanced Statistical Learning</td>
<td><strong>Module MD 4:</strong> Project Work</td>
<td><strong>Case Studies</strong> (4P) or External Internship; 8 ECTS; Accumulated graded exams</td>
<td><strong>Module MD 6:</strong> Master Thesis</td>
</tr>
<tr>
<td>Advanced Statistical Learning (4+2); 9 ECTS; Graded module exam</td>
<td>Seminar (2S); 4 ECTS;</td>
<td></td>
<td>Prerequisites: Modules MD 1 and MD 4</td>
</tr>
<tr>
<td><strong>Elective courses:</strong> Methods</td>
<td><strong>Module MD 5:</strong> Big Data</td>
<td>Graded module exams or accumulated graded exams (at least 24 ECTS in total)</td>
<td>30 ECTS; Course achievement: Advanced Seminar („Oberseminar“); Graded module exam: Master Thesis</td>
</tr>
<tr>
<td>Elective modules from catalogue</td>
<td><strong>Big Data Analytics</strong> (4+2); 9 ECTS; Graded module exam</td>
<td>(In the entire elective area — Methods and Applications — modules with a total of 45 ECTS are to be chosen.)</td>
<td></td>
</tr>
<tr>
<td><strong>Module MD 2:</strong> Statistical Theory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistical Theory (4+2); 9 ECTS; Graded module exam</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module MD 3:</strong> Data Science in Practice</td>
<td><strong>Elective courses:</strong> Applications</td>
<td><strong>Elective modules from catalogue</strong></td>
<td></td>
</tr>
<tr>
<td>Programming course (2 to 4 P); 3 ECTS; Accumulated graded exams</td>
<td>Data Science in Context (2); 3 ECTS;</td>
<td>Graded module exams or accumulated graded exams (at least 16 ECTS in total)</td>
<td></td>
</tr>
<tr>
<td>Total: 30 ECTS</td>
<td>Total: 30 ECTS</td>
<td>Total: 30 ECTS</td>
<td>Total: 30 ECTS</td>
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</table>
## Description of modules

### Compulsory Courses

<table>
<thead>
<tr>
<th>Module MD 1: Advanced Statistical Learning</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Rota</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
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<tbody>
<tr>
<td>Summer semester, annual</td>
<td>1 semester</td>
<td>1st</td>
<td>9</td>
<td>270</td>
</tr>
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1. **Module structure**

<table>
<thead>
<tr>
<th>No.</th>
<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Advanced Statistical Learning</td>
<td>L + T</td>
<td>9</td>
<td>4 + 2</td>
</tr>
</tbody>
</table>

2. **Language**

English

3. **Content**

The aspects of the statistical learning beginner’s course from the Bachelor programme (module BD 10) are enhanced and expanded. On the one hand, advanced classes of models like, e.g., neural networks (deep learning), advanced boosting and tree-based methods, generalized additive (mixed) models, enhanced approaches of regularization and Kriging methods are introduced. On the other hand, the relevance and limitations of established methods are shown, in particular, with regard to large data sets (big data). Furthermore, the fundamental differences between supervised and non-supervised learning are evolved.

4. **Competences / Qualification Goals**

The students understand advanced models and analysing methods and are aware of their limitations. They are able to adapt methods to unusually structured data. They choose appropriate methods for real data and apply them by means of statistical software. They understand the underlying mathematical theory.

5. **Examination**

Graded module exam.

6. **Formality of examination**

Written or oral exam as announced by the lecturer.

7. **Module requirements (prerequisites)**

- none -

8. **Allocation to curriculum**

Compulsory module for M. Sc. study programme Data Science

9. **Responsibility**

Prof. Dr. K. Ickstadt, Prof. Dr. J. Rahnenführer, Prof. Dr. A. Groll

**Department**

Statistics
Module MD 2: Statistical Theory

1 Module structure

<table>
<thead>
<tr>
<th>No.</th>
<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Probability Theory</td>
<td>L + T</td>
<td>4,5</td>
<td>2 + 1</td>
</tr>
<tr>
<td>2</td>
<td>Decision Theory</td>
<td>L + T</td>
<td>4,5</td>
<td>2 + 1</td>
</tr>
</tbody>
</table>

2 Language

English

3 Content

The Statistical Theory lecture (6 + 3) is divided in three parts, whereupon Probability and Decision Theory are compulsory, while the third part (Asymptotic Theory) may be chosen for another module.

The Probability Theory part deals with basics of measure and probability theory to enable students for the comprehension of more sophisticated statistical methods.

The Decision Theory part deals with basics of decision theory.

4 Competences / Qualification Goals

The students handle the formal language of statistics and understand the basics of probability theory, decision theory and mathematical statistics. They are well prepared to study, correctly apply and enhance statistical methods.

5 Examination

Graded module exam.

6 Formality of examination

Written exam on the compulsory parts.

The lecturer may demand course achievements as a prerequisite to the exam, if announced at the beginning of the course.

7 Module requirements (prerequisites)

- none -

8 Allocation to curriculum

Compulsory module for M. Sc. study programme Data Science

9 Responsibility

Prof. Dr. K. Ickstadt, Prof. Dr. C. Jentsch

Department

Statistics
## Module MD 3: Data Science in Practice

<table>
<thead>
<tr>
<th>Rota</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
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<tbody>
<tr>
<td>annual</td>
<td>1 to 2</td>
<td>1st to 2nd</td>
<td>6</td>
<td>180</td>
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### 1 Module structure

<table>
<thead>
<tr>
<th>No.</th>
<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Programming course</td>
<td>P</td>
<td>3</td>
<td>2 to 4</td>
</tr>
<tr>
<td>2</td>
<td>Data Science in Context</td>
<td>L</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

### 2 Language

English or German

### 3 Content

**No. 1:** The students participate in a software or programming language course, e.g., SAS, Julia, Python, or Advanced R, which they have not chosen in another module.

**No. 2:** The course includes introductions to international database systems, to German laws and regulations related to data (data privacy and integrity), and to the practical aspects of data science, amongst others:

Research data management (RDS) as part of the research process ensures an efficient progress of research projects, high quality comprehensible research data, and that requirements of several stakeholders were met. RDS concerns the organization of data throughout the data life cycle containing the planning, production, analysis, storage, publication, archiving, and sharing of data. This part of the lecture will explain the theory of RDS and present hands on examples from everyday research. Furthermore, the usefulness of databases in the context of RDS for placement and inquiry of research data will be shown, with a special focus on format diversity, curation and accessibility.

### 4 Competences / Qualification Goals

The students gain specialized knowledge on a software package or a programming language and apply methods from statistics and data analysis to real data using their own program code. They adopt unknown computation techniques.

The students know the important aspects of their profession.

### 5 Examination

Two accumulated graded exams.

### 6 Formality of examination

Exams as announced by the lecturers.

### 7 Module requirements (prerequisites)

- none -

### 8 Allocation to curriculum

Compulsory module for M. Sc. study programme Data Science

### 9 Responsibility

Chairman of board of examiners

Department

Statistics
Module MD 4: Project Work

<table>
<thead>
<tr>
<th>Rota</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
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</thead>
<tbody>
<tr>
<td>each semester, as offered</td>
<td>2 semesters</td>
<td>2nd to 3rd</td>
<td>12</td>
<td>360</td>
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1 Module structure

<table>
<thead>
<tr>
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<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>1a</td>
<td>Case Studies</td>
<td>P</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>1b</td>
<td>External Internship</td>
<td>S</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Seminar</td>
<td>S</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

2 Language
No. 1a: English (at least once per year) or German;
No. 1b: English or German, by arrangement
No. 2: English or German, by arrangement

3 Content
For No. 1, the students choose between internal and external exercises in preparation for professional work.
In the “Case Studies” course, the students work on one or two extensive projects dealing with real data applications. They work independently to a large extent, collaborating in teams. They choose, adopt knowledge on, and adjust methods of statistics and data analysis for the given problem. They write reports and make presentations on the methodology and their conducted extensive data analysis. They practise interactions with other fields of science and application.
During the external internship, the students work at a company or institution related to their field of study. They participate in professional working groups conducting real data analyses. They report their project and results.
In the seminar, every student reads a scientific paper, critically reflecting its contents. The main results of this work are presented in a talk, discussed and reported in written form.

4 Competences / Qualification Goals
The students work independently on a given problem, collaborating in teams. They adopt previously unknown methods and adapt them to real data tasks. They interact with co-workers from the same and other fields, advise practitioners, transfer tasks in terms of mathematics and rephrase results accordingly. They present results in written and oral form. They conduct and finish projects within a given period of time.
The students adopt knowledge on a special field of data science and comprehend and reflect the scientific work of others. They understand a new subject and explain its methods and results in class. They give critical feedback on other talks.

5 Examination
Two accumulated graded exams.

6 Formality of examination
Successful pass of reports and presentations.
Attendance may be compulsory for the courses of this module. This is determined by the lecturers in accordance with the principle of proportionality.

7 Module requirements (prerequisites)
– none –
### Module MD 4: Project Work

If there are requirements in case of conditional admission (any of modules MD Req1 to MD Req7), these have to be fulfilled by the start of the course “Case Studies” or the external internship.

<table>
<thead>
<tr>
<th></th>
<th>Allocation to curriculum</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Compulsory module for M. Sc. study programme Data Science</td>
<td>Chairman of board of examiners</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
Module MD 5: Big Data

Rota
Winter semester, annual

Duration 1 semester
Semester 2nd
ECTS points 9
Workload 270

1 Module structure

<table>
<thead>
<tr>
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<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Big Data Analytics</td>
<td>L + T</td>
<td>9</td>
<td>4 + 2</td>
</tr>
</tbody>
</table>

2 Language
English

3 Content
In this course, methods for handling and analysing large data sets are presented, with possibly large numbers of both the observations and the variables. Methods, algorithms and procedures generalized for use in a big data context, are: import and storage of data, descriptive methods (including cluster analysis) and specialized techniques of visualization, estimation and prediction for various classes of models and learning algorithms, e. g., generalized linear model, discriminant analysis, decision trees and random forests, support vector machines. Furthermore, methods for on-line learning on data streams as well as parallel computing techniques for the aforementioned methods are presented. Properties of the methods and algorithms will be discussed such as asymptotical properties like consistency, complexity, etc.

4 Competences / Qualification Goals
The students know techniques for dealing with large data sets. They handle these data and know appropriate methods for various tasks. Furthermore, they know the standard techniques to adapt methods to large data sets. Additionally, they handle problems in on-line learning for data streams and choose the appropriate methods. They know how to parallelize the methods on several cores and computers. The students apply methods to real data by means of statistical software. They understand the underlying mathematical theory.

5 Examination
Graded module exam.

6 Formality of examination
Exam as announced by the lecturer.

7 Module requirements (prerequisites)
– none –

8 Allocation to curriculum
Compulsory module for M. Sc. study programme Data Science

9 Responsibility
Prof. Dr. E. Müller

Department
Computer Science
Module MD 6: Master Thesis

<table>
<thead>
<tr>
<th>Rota</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
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<tr>
<td>each semester</td>
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<td>4th</td>
<td>30</td>
<td>900</td>
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1 Module structure

<table>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Master Thesis</td>
<td></td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Advanced Seminar (“Oberseminar”)</td>
<td>S</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

2 Language

English or German

3 Content

The Master Thesis proves the student’s ability to apply and adapt scientific methods to a problem of data science and related fields within a period of six months. Students may choose between several proposed subjects or introduce their own. The thesis can also be written at - or on collaboration with - an external public or private institution. In a special seminar, the student gives a talk to discuss the thesis' results followed by a disputation. This may be replaced by an external talk, e.g., at a company or scientific conference, in the presence of the supervisor.

4 Competences / Qualification Goals

The students independently adopt knowledge on a new subject, conduct studies, and adapt and reflect methods. They communicate the project, methods and results in a well-structured manner and discuss them critically. They compactly present and discuss their own work. They design their project independently, together with the supervisor and perhaps an external partner, and finish it within a given period of time.

5 Examination

Graded module exam: Master Thesis.

6 Formality of examination

Successful pass of thesis. Course achievement prior to submission of the thesis: presentation in the Advanced Seminar (“Oberseminar”).

7 Module requirements (prerequisites)

Successful pass of module MD 1 (Advanced Statistical Learning) and of the “Case Studies” course or an external internship of module MD 4 (Project Work).

8 Allocation to curriculum

Compulsory module for M. Sc. study programme Data Science

9 Responsibility

Chairman of board of examiners

Department

Statistics, Computer Science and Mathematics
Elective Courses

In the entire elective area – “Methods” and “Applications” – modules with a total of 45 credit points are to be chosen.

“Methods” Elective Courses

Modules with a total of at least 24 credit points are to be chosen. At the request of the students, modules other than those mentioned here may be approved as elective modules via the chairman of the examination board.

Module MD E1-1: Time Series Analysis

<table>
<thead>
<tr>
<th>No.</th>
<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>L + T</td>
<td>9</td>
<td>4 + 2</td>
</tr>
</tbody>
</table>

1. **Module structure**
   - **Duration**: 1 semester
   - **Semester**: 1st to 3rd
   - **ECTS points**: 9
   - **Workload**: 270

2. **Language**: English

3. **Content**
   - The students choose specialized courses not chosen otherwise.

4. **Competences / Qualification Goals**
   - The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

5. **Examination**
   - Graded module exam.

6. **Formality of examination**
   - Exam as announced by the lecturer(s).

7. **Module requirements (prerequisites)**
   - none

8. **Allocation to curriculum**
   - Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

9. **Responsibility**
   - Chairman of board of examiners
   - Department: Statistics
### Module MD E1-2: Survival Analysis

<table>
<thead>
<tr>
<th>Rota as offered</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
<td>9</td>
<td>270</td>
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</table>

#### Module structure

<table>
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<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Survival Analysis</td>
<td>L + T</td>
<td>9</td>
<td>4 + 2</td>
</tr>
</tbody>
</table>

#### Language

English

#### Content

The students choose specialized courses not chosen otherwise.

#### Competences / Qualification Goals

The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

#### Examination

Graded module exam.

#### Formality of examination

Exam as announced by the lecturer(s).

#### Module requirements (prerequisites)

– none –

#### Allocation to curriculum

Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

#### Responsibility

Prof. Dr. A. Groll, Prof. Dr. M. Pauly

#### Department

Statistics
# Module MD E1-3: Bootstrapping

<table>
<thead>
<tr>
<th>Rota as offered</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
<td>9</td>
<td>270</td>
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</tbody>
</table>

1. **Module structure**

<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Bootstrapping</td>
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<td>9</td>
<td>4 + 2</td>
</tr>
</tbody>
</table>

2. **Language**

English or German

3. **Content**

The students choose specialized courses not chosen otherwise.

4. **Competences / Qualification Goals**

The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

5. **Examination**

Graded module exam.

6. **Formality of examination**

Exam as announced by the lecturer(s).

7. **Module requirements (prerequisites)**

– none –

8. **Allocation to curriculum**

Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

9. **Responsibility**

Prof. Dr. C. Jentsch, Prof. Dr. M. Pauly

<table>
<thead>
<tr>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistics</td>
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</table>
Module MD E1-4: Stichprobenverfahren

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<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
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<td>150</td>
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</table>

1 Module structure

<table>
<thead>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Stichprobenverfahren</td>
<td>L + T</td>
<td>5</td>
<td>2 + 1</td>
</tr>
</tbody>
</table>

2 Language

German

3 Content

This course deals, among other things, with the theory of sampling procedures, such as stratified sampling, cluster procedures, procedures with proportional selection, and the asymptotic distribution of sampling means.

4 Competences / Qualification Goals

The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

The students master special sampling procedures. They know basic principles that help them to understand further methods in these areas. They are able to apply appropriate data collection techniques in different situations and to modify these techniques if necessary.

5 Examination

Graded module exam.

6 Formality of examination

Exam as announced by the lecturer(s).

7 Module requirements (prerequisites)

– none –

8 Allocation to curriculum

Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

9 Responsibility

Prof. Dr. Ph. Doebler, Prof. Dr. G. Knapp, Prof. Dr. C. Müller

Department

Statistics
**Module MD E1-5: Nonparametric Methods**

<table>
<thead>
<tr>
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<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
<td>4,5</td>
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<table>
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<table>
<thead>
<tr>
<th>3</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>The students choose specialized courses not chosen otherwise.</td>
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</table>

<table>
<thead>
<tr>
<th>4</th>
<th>Competences / Qualification Goals</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.</td>
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</table>

<table>
<thead>
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<table>
<thead>
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<th>6</th>
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<table>
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<tr>
<th>7</th>
<th>Module requirements (prerequisites)</th>
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<tbody>
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<table>
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<tr>
<td></td>
<td>Elective module from the “Methods” catalogue for M. Sc. study programme Data Science</td>
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<table>
<thead>
<tr>
<th>9</th>
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<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prof. Dr. C. Müller</td>
<td>Statistics</td>
</tr>
</tbody>
</table>
## Module MD E1-6: Robust Methods

<table>
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<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
<td>4.5</td>
<td>135</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Robust Methods</td>
<td>L + T</td>
<td>4.5</td>
<td>2 + 1</td>
</tr>
</tbody>
</table>

### 2 Language
English or German

### 3 Content
The students choose specialized courses not chosen otherwise.

### 4 Competences / Qualification Goals
The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

### 5 Examination
Graded module exam.

### 6 Formality of examination
Exam as announced by the lecturer(s).

### 7 Module requirements (prerequisites)
– none –

### 8 Allocation to curriculum
Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

<table>
<thead>
<tr>
<th>Responsibility</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Dr. R. Fried, Prof. Dr. C. Müller</td>
<td>Statistics</td>
</tr>
</tbody>
</table>
## Module MD E1-7: Optimization

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<th>ECTS points</th>
<th>Workload</th>
</tr>
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<tbody>
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<td>1st to 3rd</td>
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<td>150</td>
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</table>

### 1. Module structure

<table>
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<th>ECTS</th>
<th>Hours</th>
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<td>5</td>
<td>2 + 1</td>
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</table>

### 2. Language

English

### 3. Content

The students choose specialized courses not chosen otherwise.

### 4. Competences / Qualification Goals

The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

### 5. Examination

Graded module exam.

### 6. Formality of examination

Exam as announced by the lecturer(s).

### 7. Module requirements (prerequisites)

– none –

### 8. Allocation to curriculum

Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

### 9. Responsibility

Dean of Studies

Department

Mathematics
Module MD E1-8: Numerical Solution of Differential Equations

<table>
<thead>
<tr>
<th>Rota as offered</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
<td>5</td>
<td>150</td>
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</table>

<table>
<thead>
<tr>
<th>1</th>
<th>Module structure</th>
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</thead>
<tbody>
<tr>
<td>No.</td>
<td>Lecture/Course</td>
<td>Type</td>
</tr>
<tr>
<td>1</td>
<td>Numerical Solution of Differential Equations</td>
<td>L + T</td>
</tr>
</tbody>
</table>

| 2   | Language  | English |

| 3   | Content   | The students choose specialized courses not chosen otherwise. |

| 4   | Competences / Qualification Goals | The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge. |

| 5   | Examination | Graded module exam. |

| 6   | Formality of examination | Exam as announced by the lecturer(s). |

| 7   | Module requirements (prerequisites) | – none – |

| 8   | Allocation to curriculum | Elective module from the “Methods” catalogue for M. Sc. study programme Data Science |

<table>
<thead>
<tr>
<th>9</th>
<th>Responsibility</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dean of Studies</td>
<td>Mathematics</td>
</tr>
</tbody>
</table>
Module MD E1-9: Generalized Linear Models

<table>
<thead>
<tr>
<th>Rota as offered</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
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<td></td>
<td>1 semester</td>
<td>1st to 3rd</td>
<td>9</td>
<td>270</td>
</tr>
</tbody>
</table>

1 **Module structure**

<table>
<thead>
<tr>
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<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Generalized Linear Models</td>
<td>L + T</td>
<td>9</td>
<td>4 + 2</td>
</tr>
</tbody>
</table>

2 **Language**

English

3 **Content**

The course extends the methods for linear models to the general case of response distributions from the exponential family. In particular, the generalized linear model with the special cases logistic regression and loglinear model as well as models with random and mixed effects are addressed. Additionally, categorical regression and the modelling of non-linear effects via spline approaches are addressed. Moreover, basic approaches for variable selection via penalization techniques as well as semi- und Non-parametric regression models are introduced.

4 **Competences / Qualification Goals**

The students have deep knowledge about specialized methods of data science and related fields and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. The students familiarize themselves with unknown fields of knowledge.

By the **Generalized Linear Models** course, students understand different models and analysis methods. In realistic data situations, they select suitable procedures and apply them with statistical software. They understand the underlying mathematical-statistical theory.

5 **Examination**

Graded module exam.

6 **Formality of examination**

Exam as announced by the lecturer(s).

7 **Module requirements (prerequisites)**

– none –

8 **Allocation to curriculum**

Elective module from the “Methods” catalogue for M. Sc. study programme Data Science

9 **Responsibility**

Prof. Dr. A. Groll

**Department**

Statistics
Further modules from other study programmes

In addition to the above, the following modules can be chosen as “Methods” elective courses:

- from the M. Sc. study programme “Mathematik” of the Department of Mathematics:
  - Module MAT-406: Numerik II (German)
  - Module MAT-419: Diskrete Optimierung (German)
  - Module MAT-424: Nichtlineare Optimierung (German)
  - Module MAT-708: Introduction to Computational Fluid Dynamics

- from the B. Sc. study programme “Informatik” of the Department of Computer Science:
  - Module INF-BSc-222: Darstellung, Verarbeitung und Erwerb von Wissen (German)
  - Module INF-BSc-301: Digitale Bildverarbeitung (German)
  - Module INF-BSc-305: Introduction to Computational Intelligence
  - Module INF-BSc-307: Webtechnologien 1 (German)
  - Module INF-BSc-309: Webtechnologien 2 (German)

- from the M. Sc. study programme “Informatik” of the Department of Computer Science:
  - Module INF-MSc-214: Architecture and Implementation of Database Systems
  - Module INF-MSc-223: Real-Time Systems and Applications
  - Module INF-MSc-231: Praktische Optimierung (German)
  - Module INF-MSc-232: Mustererkennung (German)
  - Module INF-MSc-233: Graphische Datenverarbeitung (German)
  - Module INF-MSc-234: Commonsense Reasoning (German)
  - Module INF-MSc-241: Algorithmen und Datenstrukturen (German)
  - Module INF-MSc-401: Modellbildung, Simulation und Analyse (German)
  - Module INF-MSc-407: Verteilte Programmierung und numerische Algorithmen (German)
  - Module INF-MSc-501: Ausgewählte Kapitel der Computational Intelligence (German)
  - Module INF-MSc-502: Computer Vision
  - Module INF-MSc-505: Geometrische Modellierung (German)
  - Module INF-MSc-506: Maschinelles Lernen (German)
  - Module INF-MSc-508: Schriftenkennung (German)
  - Module INF-MSc-509: Fortgeschrittene Themen der Wissensrepräsentation (German)
  - Module INF-MSc-510: IT-Management (German)
  - Module INF-MSc-514: Computational Omics (German)
  - Module INF-MSc-518: Digitalisierung von Fertigungsprozessen (German)
  - Module INF-MSc-520: Industrial Data Science 1
  - Module INF-MSc-521: Industrial Data Science 2
  - Module INF-MSc-605: Datenbanktheorie (German)
  - Module INF-MSc-606: Algorithmische Bioinformatik (German)
  - Module INF-MSc-607: Evolutionäre Algorithmen (German)

- from the M. Sc. study programme “Automation & Robotics” of the Department of Electrical Engineering & Information Technology and the Department of Biochemical and Chemical Engineering:
  - Module AR-214: Aspects of Mathematical Modeling
  - Module AR-215: Cyber-Physical System Fundamentals
  - Module AR-308: Mathematical Simulation Techniques
  - Module AR-310: Learning in Robotics
“Applications” Elective Courses

Modules with a total of at least 16 credit points are to be chosen. At the request of the students, modules other than those mentioned here may be approved as elective modules via the chairman of the examination board.

Module MD E2-1: Bioinformatics

<table>
<thead>
<tr>
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<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>2nd to 3rd</td>
<td>9</td>
<td>270</td>
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1 Module structure

<table>
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<th>No.</th>
<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
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</table>

2 Language

English

3 Content

The students choose courses on the applications of data science in various fields.

4 Competences / Qualification Goals

The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

5 Examination

Graded module exam.

6 Formality of examination

Exam as announced by the lecturer(s).

7 Module requirements (prerequisites)

– none –

8 Allocation to curriculum

Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

9 Responsibility

Prof. Dr. J. Rahnenführer

Department

Statistics
## Module MD E2-2: Toxicology

<table>
<thead>
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<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
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<tbody>
<tr>
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1. **Module structure**

<table>
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2. **Language**

English

3. **Content**

The students choose courses on the applications of data science in various fields.

4. **Competences / Qualification Goals**

The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

5. **Examination**

Graded module exam.

6. **Formality of examination**

Exam as announced by the lecturer(s).

7. **Module requirements (prerequisites)**

– none –

8. **Allocation to curriculum**

Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

9. **Responsibility**

Chairman of board of examiners

**Department**

Statistics
# Module MD E2-3: Econometrics

<table>
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## Module structure

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## Language

English

## Content

The students choose courses on the applications of data science in various fields.

## Competences / Qualification Goals

The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

## Examination

Graded module exam.

## Formality of examination

Exam as announced by the lecturer(s).

## Module requirements (prerequisites)

– none –

## Allocation to curriculum

Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

## Responsibility

JProf. Dr. A. Arsova, Prof. Dr. C. Jentsch

## Department

Statistics
## Module MD E2-4: Econometrics of treatment effects and policy evaluation

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<th>Content</th>
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<thead>
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<tr>
<td></td>
<td>Prof. Dr. C. Jentsch</td>
</tr>
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1 Module structure

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<tbody>
<tr>
<td>1</td>
<td>Natürlichsprachige Systeme</td>
<td>L + T</td>
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<td>2 + 2</td>
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</table>

2 Language

German

3 Content

Modern computer systems increasingly need to process data in natural language, most obviously when searching for text on the Internet, but also increasingly through dialogue systems with virtual agents, automatic translation, or the analysis of large amounts of text, such as when extracting information from news reports, ratings and comments in social media.

Natural language systems classically consist of morphological analysis, syntax analysis (and generation) and semantic analysis, often based on complex systems of rules. Increasingly, however, purely statistical models from the field of artificial intelligence are also being used, such as word embeddings, which are trained on large amounts of data.

This module deals with current, selected topics in the field of natural language systems and statistical language processing, especially in the areas of text classification, cluster analysis of text, topic models such as LDA and the underlying approaches such as the vector space model for text, embeddings, and graphical models.

4 Competences / Qualification Goals

The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

Students acquire advanced methods of natural language processing and gain a deeper understanding of automatic language processing by dealing with classical, application-oriented and interdisciplinary problems. Through the confrontation between the ambiguity and inaccuracy of text with the normally highly structured methods of computer science, they become aware of limitations and possibilities.

5 Examination

Graded module exam.

6 Formality of examination

Exam as announced by the lecturer(s).

7 Module requirements (prerequisites)

– none –

8 Allocation to curriculum

Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

9 Responsibility

Prof. Dr. K. Morik, Prof Dr. E. Schubert

Department

Computer Science
Module MD E2-6: Control Theory and Applications

<table>
<thead>
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<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
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1 Module structure

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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tr>
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<td>Control Theory and Applications</td>
<td>L + T</td>
<td>7</td>
<td>3 + 2</td>
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</tbody>
</table>

2 Language

English

3 Content

- Modelling of dynamic systems: First principles models, state space representation, DAE systems, classes of systems, models, and signals, linearity and causality, steady states, operability, singular value decomposition, stability, linearization.
- Linear state space theory: Autonomous behaviour, eigenvalues, eigenvectors, Jordan form, controllability and pole assignment, LQ-optimal control, observability, observers, observer-based control, Kalman decomposition.
- Laplace transform and transfer matrices: Introduction to the Laplace transform, transfer functions, poles, zeros, minimal realization, zeros of multivariable systems, frequency response, input-output stability.
- Discrete-time and sampled data systems: z-transform, z-transform of sampled data systems, stability, dead-beat control, w-transform

Literature:

- Handouts

4 Competences / Qualification Goals

The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

The students have a solid background in control theory to solve automation problems in robotics as well as in production processes of all kinds.

5 Examination

Graded module exam.

6 Formality of examination

Exam as announced by the lecturer(s).

7 Module requirements (prerequisites)

- none –

8 Allocation to curriculum

Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

9 Responsibility

Prof. Dr. S. Engell

Department

Biochemical and Chemical Engineering
# Module MD E2-7: Reliability and Material Fatigue

<table>
<thead>
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<th>Rota as offered</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
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<tbody>
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## Module structure

<table>
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<th>Hours</th>
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<td>9</td>
<td>4 + 2</td>
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</table>

## Language

English or German

## Content

The students choose courses on the applications of data science in various fields.

## Competences / Qualification Goals

The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

## Examination

Graded module exam.

## Formality of examination

Exam as announced by the lecturer(s).

## Module requirements (prerequisites)

– none –

## Allocation to curriculum

Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

## Responsibility

Prof. Dr. C. Müller

Department

Statistics
Module MD E2-8: Quality Control

<table>
<thead>
<tr>
<th>Rota as offered</th>
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<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 semester</td>
<td>2nd to 3rd</td>
<td>9</td>
<td>270</td>
</tr>
</tbody>
</table>

1. **Module structure**
   - **No.**
   - **Lecture/Course**
   - **Type**
   - **ECTS**
   - **Hours**
   - 1 Quality Control L + T 9 4 + 2

2. **Language**
   - English or German

3. **Content**
   - The students choose courses on the applications of data science in various fields.

4. **Competences / Qualification Goals**
   - The students have deep knowledge about methods of data science for special fields of application and apply them appropriately. They understand their theoretical background and choose suitable methods for a given problem. They apply methods to real data by means of software.

5. **Examination**
   - Graded module exam.

6. **Formality of examination**
   - Exam as announced by the lecturer(s).

7. **Module requirements (prerequisites)**
   - none

8. **Allocation to curriculum**
   - Elective module from the “Applications” catalogue for M. Sc. study programme Data Science

9. **Responsibility**
   - Prof. Dr. C. Müller

   **Department**
   - Statistics
Further modules from other study programmes

In addition to the above, the following modules can be chosen as “Applications” elective courses:

- from the M. Sc. study programme “Automation & Robotics” of the Department of Electrical Engineering & Information Technology and the Department of Biochemical and Chemical Engineering:
  - Module AR-206: Data-Based Dynamic Modeling
**Module MD Req1: Advanced Mathematics**

<table>
<thead>
<tr>
<th>Rota</th>
<th>Duration</th>
<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
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<tbody>
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<td>Winter semester, annual</td>
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<td>7</td>
<td>210</td>
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1. **Module structure**

<table>
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<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
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<td>7</td>
<td>3 + 2</td>
</tr>
</tbody>
</table>

2. **Language**

   English

3. **Content**

   - Linear Algebra: Vector spaces, matrices and equation systems, linear maps, Jordan-, LU-, QR-, and singular value decomposition, numerical aspects.
   - Differential Equation: Linear systems, differential equations with constant coefficients.
   - Laplace-Transform: Definition, convolution and application to differential equations.
   - Differential Calculus with several variables: Derivatives, inverse and implicit functions, Taylor expansion and extreme values.
   - Variational Calculus.

   **Literature:**
   - Bajpai, Avinash C., Mathematics for engineers and scientists
   - Meyer, R.M., Essential mathematics for applied fields
   - Lancaster, P., Tismenetsky, M., The theory of matrices
   - Lang, S., Linear algebra
   - Slides

4. **Competences / Qualification Goals**

   The students are acquainted with fundamental mathematical techniques and thus prepared for their future courses. They understand the underlying mathematical structures in their field.

5. **Examination**

   Module exam.

6. **Formality of examination**

   Written exam (2 hours).

7. **Module requirements (prerequisites)**

   - none -

8. **Allocation to curriculum**

   Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

9. **Responsibility**

   Dean of Studies
   Department Mathematics
Module MD Req2: Data Structures and Programming

<table>
<thead>
<tr>
<th>No.</th>
<th>Module structure</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
</tr>
</thead>
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<td>Reading Course Data Structures and Programming</td>
<td>reading course</td>
<td>10</td>
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</tbody>
</table>

2 Language
English

3 Content
- Programming Languages: introduction to Java; concepts of structured and object oriented programming.
- Algorithms: sorting and searching on lists, trees and graphs.
- Object oriented software: classes; secret principle and encapsulation; message exchange; inheritance; hierarchies; exception handling; genericity; object oriented design.
- Programming in Java.

Literature:

4 Competences / Qualification Goals
Students deeply understand the informal basics for the description of programming languages and their implementation within the framework of the Java programming language. Students handle the basics of object-oriented program design, independently formulate solution algorithms for given problems and implement them as Java programs. They deeply understand selected designs for object-oriented software construction and evaluate their usability.

5 Examination
Module exam.

6 Formality of examination
Examination based on the book’s contents.

7 Module requirements (prerequisites)
- none –

8 Allocation to curriculum
Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

9 Responsibility
Dean of Studies

Department
Computer Science
Module MD Req3: Information Systems

<table>
<thead>
<tr>
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<th>Semester</th>
<th>ECTS points</th>
<th>Workload</th>
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1 Module structure

<table>
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<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>Reading Course Information Systems</td>
<td>reading course</td>
<td>5</td>
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</tr>
</tbody>
</table>

2 Language

English

3 Content

The course deals with the architecture and use of information systems, especially database and information retrieval systems. Powerful, declarative query and change languages are traced back to computer-based, procedural execution plans. The modelling and formalisation of applications as well as the practical handling of an object-relational database system (ORACLE) is explained.

Literature:
Lecture materials, and some references given therein, of the course “Informationssysteme” by Prof. Teubner of the Faculty of Computer Science

4 Competences / Qualification Goals

Students understand the basics of syntax and semantics of information system services, know the architecture of information systems, and perform the development cycle of applications based on this.

5 Examination

Module exam.

6 Formality of examination

Examination based on the lecture materials.

7 Module requirements (prerequisites)

- none -

8 Allocation to curriculum

Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

9 Responsibility

Dean of Studies

Department

Computer Science
## Module MD Req4: Probability

<table>
<thead>
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<th>Duration</th>
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### 1 Module structure

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<th>Hours</th>
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<td>reading course</td>
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</table>

### 2 Language

English

### 3 Content

- Concepts of probability, distributions, conditional probability and independence, Bayes’ rule, sequences of events.
- Sampling, Binomial distribution, Normal approximation, Poisson distribution.
- Random variables, expectation and variance.
- Probability densities, Exponential and Gamma distributions, substitutions, cumulative distribution functions.
- Joint distributions, Uniform and Normal distributions.
- Dependence, conditional distributions, covariance and correlation.

**Literature:**
Jim Pitman: Probability. Springer 1993: Chapters 1, 2.1, 2.2, 2.5, 3.1-3.5, 4.1, 4.2, 4.4, 4.5, 5.1-5.3, 6.

### 4 Competences / Qualification Goals

Students gain a deep understanding of probability. They independently integrate statistical problems in the context of probability theory and solve them using appropriate methods. Students apply mathematical proof techniques.

### 5 Examination

Module exam.

### 6 Formality of examination

Examination based on the book chapters.

### 7 Module requirements (prerequisites)

- none -

### 8 Allocation to curriculum

Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

### 9 Responsibility

Prof. Dr. K. Ickstadt, Prof. Dr. C. Jentsch

**Department**

Statistics
Module MD Req5: Inference

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1 Module structure

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<th>Type</th>
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<th>Hours</th>
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<tr>
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<td>Reading Course Inference</td>
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</table>

2 Language

English

3 Content

- Parametric point estimation: method of moments and maximum likelihood; consistency; sufficiency; error, bias and loss; completeness; Rao-Cramer-bound; invariance; Bayesian estimation.
- Parametric interval estimation: confidence intervals, especially for Normal distribution parameters, finding methods, Bayesian estimation.
- Tests of hypotheses: simple and composite hypotheses, loss function, (uniformly) most powerful tests, unbiased tests, tests for (multivariate) Normal distribution parameters, Chi-square tests, relation to confidence intervals.

Literature:

4 Competences / Qualification Goals

Students calculate point and interval estimators and carry out significance tests. They prove basic properties of estimators and tests. Students apply the methods to real data.

5 Examination

Module exam.

6 Formality of examination

Examination based on the book chapters.

7 Module requirements (prerequisites)

- none -

8 Allocation to curriculum

Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

9 Responsibility

Prof. Dr. R. Fried, Prof. Dr. C. Müller, JProf. Dr. K. Schorning

Department

Statistics
# Module MD Req6: Linear Models

<table>
<thead>
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<th>Duration</th>
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<th>ECTS points</th>
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## 1 Module structure

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<td>Reading Course Linear Models</td>
<td>reading course</td>
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## 2 Language

English

## 3 Content

- Introduction to regression models: real data examples, simple and multiple linear models, binary response models.
- Linear model components: parameters, covariates, residuals, assumptions.
- Parameter estimation: coefficients and error variance.
- Hypothesis tests and confidence intervals: F-Tests, confidence regions, prediction intervals.
- Model choice: variable selection, prediction evaluation, criteria.

### Literature:

## 4 Competences / Qualification Goals

Students calculate point and interval estimators and carry out significance tests in the context of the linear model. They have knowledge on model selection. Students apply the methods to real data.

## 5 Examination

Module exam.

## 6 Formality of examination

Examination based on the book chapters.

## 7 Module requirements (prerequisites)

- none -

## 8 Allocation to curriculum

Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

## 9 Responsibility

Prof. Dr. A. Groll, Prof. Dr. K. Ickstadt, Dr. T. Ziebach

Department
Statistics
Module MD Req7: Introductory Case Studies

Rota:
every semester

Duration:
1 semester

Semester:
beginning of programme

ECTS points:
5

Workload:
150

<table>
<thead>
<tr>
<th>No.</th>
<th>Lecture/Course</th>
<th>Type</th>
<th>ECTS</th>
<th>Hours</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Introductory Case Studies (parts of the course “Fallstudien I” of the module BD 14 of the Bachelor programme Data Science)</td>
<td>P</td>
<td>5</td>
<td>4 (for 3/7 of the sem.)</td>
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</table>

2 Language
English, enclosed in a German course

3 Content
The aim of the course is to familiarise students with the independent evaluation of statistical data sets. In addition to the provision of a catalogue of basic standard procedures for data evaluation, a central learning objective is the appropriate presentation of the methodological approach and the evaluation results in verbal and written form. In order to achieve these learning goals, students have to work in small groups (three to four members) on three projects. The time frame for each project is three to six weeks, depending on the level of difficulty. The intermediate and final results of the statistical evaluation are presented alternately by the groups. After completion of each project, each student must submit a short, written report in which the results achieved in the group and the methodology used are presented in an appropriate manner.

4 Competences / Qualification Goals
Students work independently according to scientific criteria and report orally and in writing on their work. Students apply statistical methods to real data sets, modify the methods if necessary and work out methods unknown to them. They derive solutions to problems and reflect on them. They work together in groups. They prepare and give presentations, explaining statistical methods and communicating results. They discuss their own and other methods, results and reports with others. They complete the projects within a short, given time.

5 Examination
Module exam.

6 Formality of examination
Written reports and oral presentations.

7 Module requirements (prerequisites)
- none -

8 Allocation to curriculum
Possible requirement in case of conditional admission to the M. Sc. study programme Data Science

9 Responsibility
Chairman of board of examiners

Department
Statistics