

Handbook of Modules

for the

Master Study Programme Data Science

(Terms of study 2019/2020)

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Overview of modules

Compulsory Courses

No.	MODULE NAME	Lectures/courses	ECTS points
MD 1	ADVANCED STATISTICAL LEARNING	Advanced Statistical Learning	9
MD 2	STATISTICAL THEORY	Statistical Theory	9
MD 3	DATA SCIENCE IN PRACTICE	Programming course Data Science in Context	3 3
MD 4	PROJECT WORK	Case Studies / External Internship Seminar	8 4
MD 5	BIG DATA	Big Data Analytics	9
MD 6	MASTER THESIS	Master Thesis Advanced Seminar	27 3

Elective courses

(to choose modules with a total of 45 ECTS points)

CATALOGUE OF MODULES	No.	Lectures/courses	ECTS points	Language
METHODS (to choose modules with a total of at least 24 ECTS points)	MD E1-1	Time Series Analysis	9	English
	MD E1-2	Survival Analysis	9	English
	MD E1-3	Bootstrapping	9	English
	MD E1-4	Stichprobenverfahren	5	German
	MD E1-5	Nonparametric Methods	4,5	English or German
	MD E1-6	Robust Methods	4,5	English or German
	MD E1-7	Optimization	5	English
	MD E1-8	Numerical Solution of Differential Equations	5	English
	MD E1-9	Generalized Linear Models	9	English
	Further modules from other study programmes			
Other modules upon request				English or German
APPLICATIONS (to choose modules with a total of at least 16 ECTS points)	MD E2-1	Bioinformatics	9	English
	MD E2-2	Toxicology	9	English
	MD E2-3	Econometrics	9	English
	MD E2-4	Econometrics of treatment effects and policy evaluation	4,5	English
	MD E2-5	Natürlichsprachige Systeme	7	German
	MD E2-6	Control Theory and Applications	7	English

	MD E2-7	Reliability and Material Fatigue	9	English or German
	MD E2-8	Quality Control	9	English or German
	Other modules upon request			English or German

Possible requirements in case of conditional admission

No.	MODULE NAME	Lectures/courses	ECTS points
MD Req1	ADVANCED MATHEMATICS	Advanced Engineering Mathematics	7
MD Req2	DATA STRUCTURES AND PROGRAMMING	Reading Course Data Structures and Programming	10
MD Req3	INFORMATION SYSTEMS	Reading Course Information Systems	5
MD Req4	PROBABILITY	Reading Course Probability	5
MD Req5	INFERENCE	Reading Course Inference	5
MD Req6	LINEAR MODELS	Reading Course Linear Models	5
MD Req7	INTRODUCTORY CASE STUDIES	Introductory Case Studies	5

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

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

Starting in summer semester

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

1st semester	2nd semester	3rd semester	4th semester
Module MD 1: Advanced Statistical Learning Advanced Statistical Learning (4+2); 9 ECTS; Graded module exam	Module MD 4: Project Work Seminar (2S); 4 ECTS;	Case Studies (4P) or External Internship; 8 ECTS; Accumulated graded exams	Module MD 6: Master Thesis Prerequisites: Modules MD 1 and MD 4
Elective courses: Methods Elective modules from catalogue	Module MD 5: Big Data Big Data Analytics (4+2); 9 ECTS; Graded module exam	Graded module exams or accumulated graded exams (at least 24 ECTS in total)	30 ECTS; Course achievement: Advanced Seminar („Oberseminar“); Graded module exam: Master Thesis
	Module MD 2: Statistical Theory Statistical Theory (4+2); 9 ECTS; Graded module exam		
Module MD 3: Data Science in Practice Programming course (2 to 4 P); 3 ECTS; Accumulated graded exams	Elective courses: Applications Data Science in Context (2); 3 ECTS;	Elective modules from catalogue Graded module exams or accumulated graded exams (at least 16 ECTS in total)	
Total: 30 ECTS	Total: 30 ECTS	Total: 30 ECTS	Total: 30 ECTS

Description of modules

Compulsory Courses

Module MD 1: Advanced Statistical Learning				
Rota Summer semester, annual	Duration 1 semester	Semester 1st	ECTS points 9	Workload 270

1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Advanced Statistical Learning	L + T	9	4 + 2
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

Rota Winter semester, annual	Duration 1 semester	Semester 1st	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Probability Theory	L + T	4,5	2 + 1
	2	Decision Theory	L + T	4,5	2 + 1
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

Rota annual	Duration 1 to 2 semesters	Semester 1st to 2nd	ECTS points 6	Workload 180
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Programming course	P	3	2 to 4
	2	Data Science in Context	L	3	2
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

Rota each semester, as offered	Duration 2 semesters	Semester 2nd to 3rd	ECTS points 12	Workload 360
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1a	Case Studies	P	8	4
	1b	External Internship		8	
	2	Seminar	S	4	2
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.	
8	Allocation to curriculum Compulsory module for M. Sc. study programme Data Science	
9	Responsibility Chairman of board of examiners	Department Statistics

Module MD 5: Big Data

Rota Winter semester, annual	Duration 1 semester	Semester 2nd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Big Data Analytics	L + T	9	4 + 2
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

Rota each semester	Duration 1 semester	Semester 4th	ECTS points 30	Workload 900
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Master Thesis		27	
	2	Advanced Seminar ("Oberseminar")	S	3	
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				
Rota as offered	Duration	Semester	ECTS points	Workload
	1 semester	1st to 3rd	9	270

1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Time Series Analysis	L + T	9	4 + 2
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

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Survival Analysis	L + T	9	4 + 2
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 Prof. Dr. A. Groll, Prof. Dr. M. Pauly			Department Statistics	

Module MD E1-3: Bootstrapping

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Bootstrapping	L + T	9	4 + 2
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			Department Statistics	

Module MD E1-4: Stichprobenverfahren

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Stichprobenverfahren	L + T	5	2 + 1
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. Doeblner, Prof. Dr. G. Knapp, Prof. Dr. C. Müller		Department Statistics		

Module MD E1-5: Nonparametric Methods

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 4,5	Workload 135
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Nonparametric Methods	L + T	4,5	2 + 1
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. Müller		Department Statistics		

Module MD E1-6: Robust Methods

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 4,5	Workload 135
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Robust Methods	L + T	4,5	2 + 1
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. R. Fried, Prof. Dr. C. Müller			Department Statistics	

Module MD E1-7: Optimization

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Optimization	L + T	5	2 + 1
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

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Numerical Solution of Differential Equations	L + T	5	2 + 1
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 E1-9: Generalized Linear Models

Rota as offered	Duration 1 semester	Semester 1st to 3rd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Generalized Linear Models	L + T	9	4 + 2
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: Schrifterkennung](#) (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				
Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 9	Workload 270

1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Bioinformatics	L + T	9	4 + 2
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

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Toxicology	L + T	9	4 + 2
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

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Econometrics	L + T	9	4 + 2
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 JProf. Dr. A. Arsova, Prof. Dr. C. Jentsch			Department Statistics	

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

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 4,5	Workload 135
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Econometrics of treatment effects and policy evaluation	L + T	4,5	2 + 1
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. C. Jentsch		Department Statistics		

Module MD E2-5: Natürlichsprachige Systeme

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 7	Workload 180
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Natürlichsprachige Systeme	L + T	7	2 + 2
2	Language German				
3	Content <p>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.</p> <p>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.</p> <p>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.</p>				
4	Competences / Qualification Goals <p>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.</p> <p>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.</p>				
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

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 7	Workload 210
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Control Theory and Applications	L + T	7	3 + 2
2	Language English				
3	Content <ul style="list-style-type: none"> 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. Design of single-loop controllers: Internal stability, performance specification, classical SISO controller design, robust stability and performance, performance limitations Discrete-time and sampled data systems: z-transform, z-transform of sampled data systems, stability, dead-beat control, w-transform Literature: <ul style="list-style-type: none"> Handouts S. Skogestad, Postlethwaite: Multivariable Feedback Control, Wiley, 1996. K. Zhou, J. Doyle: Essentials of Robust Control, Prentice Hall, 1998. 				
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

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 9	Workload 270
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Reliability and Material Fatigue	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		

Module MD E2-8: Quality Control

Rota as offered	Duration 1 semester	Semester 2nd to 3rd	ECTS points 9	Workload 270
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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](#)

Possible requirements in case of conditional admission

Module MD Req1: Advanced Mathematics					
Rota Winter semester, annual	Duration 1 semester	Semester beginning of programme	ECTS points 7	Workload 210	
1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Advanced Engineering Mathematics	L + T	7	3 + 2
2	Language English				
3	Content <ul style="list-style-type: none"> 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. Stability of Differential Equations: Theorems of Ljapunov and Poincaré-Ljapunov. Variational Calculus. Literature: <ul style="list-style-type: none"> 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

Rota every semester	Duration 1 semester	Semester beginning of programme	ECTS points 10	Workload 300
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Reading Course Data Structures and Programming	reading course	10	
2	Language English				
3	Content <ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> • James T. Streib, Takako Soma: Guide to Data Structures: A Concise Introduction Using Java. Springer 2017. • Takako Soma, James T. Streib: Guide to Java: A Concise Introduction to Programming. Springer 2014. 				
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

Rota every semester	Duration 1 semester	Semester beginning of programme	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Reading Course Information Systems	reading course	5	
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

Rota every semester	Duration 1 semester	Semester beginning of programme	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Reading Course Probability	reading course	5	
2	Language English				
3	Content <ul style="list-style-type: none"> • 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

Rota every semester	Duration 1 semester	Semester beginning of programme	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Reading Course Inference	reading course	5	
2	Language English				
3	<p>Content</p> <ul style="list-style-type: none"> • 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. <p>Literature: Alexander M. Mood, Franklin A. Graybill, Duane C. Boes: Introduction to the Theory of Statistics. McGraw-Hill 1974: Chapters VII, VIII, IX.1-IX.6.</p>				
4	<p>Competences / Qualification Goals</p> <p>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.</p>				
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

Rota every semester	Duration 1 semester	Semester beginning of programme	ECTS points 5	Workload 150
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Reading Course Linear Models	reading course	5	
2	Language English				
3	Content <ul style="list-style-type: none"> • 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: Thomas Kneib, Stefan Lang, Ludwig Fahrmeir, Brian D. Marx: Regression: Models, Methods and Applications. Springer 2015: Chapters 1, 2.1-2.3, 3.				
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
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1	Module structure				
	No.	Lecture/Course	Type	ECTS	Hours
	1	Introductory Case Studies (parts of the course "Fallstudien I" of the module BD 14 of the Bachelor programme Data Science)	P	5	4 (for 3/7 of the sem.)
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		