LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Module Catalogue

Master's Programme: Statistics and Data Science

(Master of Science, M.Sc.)

(120 ECTS credits; for the start of studies in the summer semester)

Based on the *Prüfungs- und Studienordnung* of 8 December 2021

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Abbreviations and annotations

CP	credit points, ECTS credits
ECTS	European Credit Transfer and Accumulation System
h	hours
SoSe	summer semester
SWS	contact hours
WiSe	winter semester
WP	compulsory elective course/module
P	mandatory course/module

1. The ECTS credits assigned in the module catalogue are designated as follows: credit points not listed in parentheses are awarded when the relevant examination of the module or module parts has/have been completed successfully. Credit points in parentheses are listed for calculation purposes only.

2. The semester, in which a module should be taken, can either be mandatory or considered a recommendation, depending on the information in Anlage 2 of the *Prüfungs- und Studienordnung* of your degree programme. In this module catalogue, the options are indicated as "scheduled semester" or "recommended semester".

3. Please note: The module catalogue is for orientation purposes only while the provisions of the *Prüfungs- und Studienordnung* of your degree programme in the current version (in German only) are legally binding. See www.lmu.de/studienangebot and select your degreeprogramme.

Module: P 1 Statistical Modelling

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self study hours	ECTS
Lecture	P 1.1 Statistical Modelling (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise	P 1.2 Statistical Modelling (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 1.3 Lecture Series on Statistical Modelling	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 12 ECTS credits have to be acquired. Class attendance averages about 8 contact hours. Including time for self-study, 360 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, basic knowledge of regression modelling and statistical inference is required.
Semester	Recommended semester: 1
Duration	The completion of the module takes 2 semesters.
Content	In this course, the fundamental concepts of statistical modelling including different approaches are introduced. The wide range of regression models including generalized linear and additive models, duration time models is covered. Furthermore, latent variable models, measurement errors and beyond mean regression are discussed. Strategies for model selection and basic aspects of directed cyclic graphs (DAGs) and causal inference complete the lecture.
Learning outcomes	The students understand and apply different types of statistical models in real world problems. They know how to perform model selection and model checking and they are able to bridge theoretical concepts and applied questions.

Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Küchenhoff
Language(s)	English
Additional information	None

Module: P 3 Statistical Inference

Programme	Master Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 3.1 Statistical Inference (Lecture)	WiSe and SoSe	60 h (4 SWS)	120 h	(6)
Exercise	P 3.2 Statistical Inference (Exercise Course)	WiSe and SoSe	30 h (2 SWS)	60 h	(3)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 6 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other programmes	Masterstudiengang Versicherungs- und Finanzmathematik
Elective guidelines	None
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular an appropriate background in probability theory, differential calculus (multivariate), integration, matrix calculus as well as in basics inference concepts is required.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	In this course students will learn different estimation and inference techniques. As a starting point, the classical theory of point estimation and tests will be introduced, including important concepts such as loss function, risk function or multiple testing procedures. Then, likelihood-based estimation of statistical models (multi-dimensional) is presented. Important tools such as the score function, Fisher information, asymptotic normality, variance bounds, confidence intervals and likelihood ratio tests are discussed Then, Bayesian (multi-dimensional) inference methods, including modern sampling approaches such as Gibbs sampling, or in general, Markov-Chain Monte Carlo

	approaches, as well as variational Bayes and approximations such as the Laplace approximation, are presented. Finally, the non-parametric and parametric bootstrap for estimating standard deviations, confidence intervals and statistical tests is discussed.
Learning outcomes	Students will get knowledge of fundamental concepts of statistical inference and reasoning. They will understand important building blocks for statistical inference. Furthermore, they will be able to apply important tools for the estimation of parameters of statistical models and for the estimation of the distributions of estimates of these parameters. Furthermore, they will know the weaknesses and strengths of each approach.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Heumann
Language(s)	English
Additional information	None

Module: WP 7 Deep Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course mandatory	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 7.1 Deep Learning (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 7.2 Deep Learning (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical inference, statistical modelling, and machine learning. Moreover, a background in optimization techniques is advisable.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The course will lay out a brief history of deep learning and subsequently introduces the basic structure of neural networks including their mathematical foundation. After discussing the extension of a single hidden layer network to more complex, deeper feedforward neural networks, their regularization is discussed and a detailed explanation of the different optimization routines for neural networks is given. A second larger part of the lecture and exercise course will introduce convolutional neural networks (CNNs). This includes properties and components of CNNs as well as different variations of convolution operations and an overview of modern CNN architectures. A third part of the course introduces recurrent neural networks (RNNs), their optimization, different architectures and applications of RNNs. After discussing modern approaches based on the attention mechanism and transformers, we turn to different types of autoencoders, variational

	autoencoders, and generative adversarial networks as well as evaluation of generative models.
Learning outcomes	The students understand the basic principles of deep learning, their optimization and the functionality of prominent architectures including CNNs, RNNs, AE, and Generative Models. They are able to formulate, implement and train appropriate architectures for practical use cases.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 10 Diagnostic Accuracy Studies

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 10.1 Diagnostic Accuracy Studies (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 10.2 Diagnostic Accuracy Studies (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and machine learning.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The course covers the most important aspects in the design, analysis and interpretation of diagnostic accuracy studies. The first part of the course starts by introducing basic concepts including sensitivity, specificity, predictive values, diagnostic likelihood ratios and receiver operating characteristic curves and statistical techniques to estimate these quantities. It also discusses more advanced topics including for instance imperfect reference tests, verification bias, sample size calculation and meta-analysis of diagnostic accuracy studies. The second part of the lecture takes a broader view on the topic by discussing important issues that are related to diagnostic accuracy, including for instance the design and evaluation of clinical prediction models for the diagnosis and prognosis of disease and more general concepts and methods that allow to describe and account for the

	accuracy of the collected variables in the modelling of communicable and non-communicable disease.
Learning outcomes	At the completion of the course, students are familiar with the most important concepts and methods to describe and analyze diagnostic accuracy studies. They are aware of challenges and pitfalls in the design, analysis and interpretation of these studies and they are able to choose adequate statistical methods that allow them to address these issues.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Boulesteix
Language(s)	English
Additional information	None

Module: WP 13 Introduction to Medical Terminology

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 13.1 Introduction to Medical Terminology (Lecture)	SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 13.2 Introduction to Medical Terminology (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	None
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module introduces the students to basic terminology in different fields of medical practice and related fields like epidemiology. The students learn basic principles of classification schemes for diseases and characteristic elements of doctors' professional language,
Learning outcomes	The students get some familiarity with medical terminology and professional language. This improves their communication skills in interdisciplinary projects from medicine and biostatistics, in particular their ability to operationalize and formalize medical questions into statistical models.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Dean of Studies (currently: Augustin)
Language(s)	English
Additional information	None

Module: WP 14 Data Collection and Questionnaire Design

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 14.1 Data Collection and Questionnaire Design (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 14.2 Data Collection and Questionnaire Design (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The social survey is a research tool of fundamental importance across a range of disciplines and is widely used in applied research and as evidence to inform policy making. This course considers the process of conducting a survey, with an emphasis on practical aspects of survey design and implementation, as well as factors that influence the quality of survey data. The course will also cover key statistical concepts and procedures in sample design and estimation. The course is structured around the following topics: Introduction of the Total Survey Error framework, questionnaire design, pretesting and fieldwork, alternative modes of data collection, survey sampling, and post-survey processing and estimation.
Learning outcomes	By the end of the course students will be able to apply the key terminology used in large-scale survey design. They will understand factors that influence data quality, including coverage, sampling, and nonresponse and be able to evaluate different survey methods and sampling techniques. In addition, students will be able to identify methods for assessing the quality of survey data and have a

	clear understanding of the steps involved in designing and planning a survey.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kreuter
Language(s)	English
Additional information	None

Module: WP 15 Official Statistics on Households, Enterprises, Economies and Populations

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 15.1 Official Statistics on Households, Enterprises, Economies and Populations (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 15.2 Official Statistics on Households, Enterprises, Economies and Populations (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This course first reflects on official statistics about social matters like income, living conditions, poverty measures, and unemployment. Hereby, a focus is put on the measurement of social and abstract constructs. Later, the most important voluntary and compulsory surveys conducted by official statistics are discussed, as well as recent developments in the area of processed produced external data and so-called smart statistics. Then, the module turns to business statistics with respect to national accounts, terms of trade, and indicators of economic development. Furthermore, demographic models are examined.
Learning outcomes	After this course students will know the benefits as well as the difficulties trying to quantify social constructs. They are familiar with the major surveys in official statistics, their specific characteristics and their special quality standards. They understand the specific requirements as

	well as methodological opportunities and challenges of new data sources.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Augustin
Language(s)	English
Additional information	The module plays an important role in the EMOS specialization.

Module: WP 17 Econometric Theory

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 17.1 Econometric Theory (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 17.2 Econometric Theory (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and on statistical inference.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module gives an overview of modern econometric theory and its central modelling techniques. Methods for asymptotic inference in interdependent or dynamic structural systems are introduced and compared. Another focus is on econometric analysis of latent structures, ranging from choices models to models explicitly taking into account measurement error or misclassifications.
Learning outcomes	Students have a good overview of fundamental questions and techniques in econometric theory. They understand the power of the different methods, their technical requirements and their limitations. They know to handle situations with latent variables.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 18 Time Series

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 18.1 Time Series (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 18.2 Time Series (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This course introduces the concept of time series in both theoretical and applied frameworks. At the beginning, time series as a discrete version of certain continuous stochastic processes are presented. The discussion is supplemented with practical examples using economic figures such as GDP, industrial production indices or financial figures such as stock prices. Decompositions of time series are discussed, and filtering methods are introduced. This course is focused on linear time series models, in particular ARIMA. A major part of the course will be to investigate this class of models in terms of estimation, prediction and especially the statistical significance of the results gained from the analysis. Finally, some heteroscedasticity models are presented, namely ARCH and GARCH models with respect to financial time series.
Learning outcomes	The students are able to apply time series methods to analyze data with a time domain. They are able to use the ARIMA and (G)ARCH class of models to investigate economic and financial data, that is, estimate the model, test

	the significance of their results and use that model for prediction.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Dean of Studies (currently: Augustin)
Language(s)	English
Additional information	None

Module: WP 21 Regression for Correlated Data

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 21.1 Regression for Correlated Data (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 21.2 Regression for Correlated Data (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and machine learning. Moreover, basic proficiency in R (scripted analyses, data visualization) is highly recommended.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This course focuses on the theory and applications of flexible regression models for outcomes with known dependency structures, i.e., longitudinal, spatial or spatio-temporal, hierarchically grouped and functional data. Exercises and case studies on model choice, model diagnostics, inference and interpretation of models for correlated data and comparisons of their various R implementations serve as the applied basis for a theoretical perspective that focuses on commonalities between regularized empirical risk minimization, penalized maximum likelihood inference, Bayesian inference with informative prior hierarchies and (latent) Gaussian process methods.
Learning outcomes	Students will be able to perform, critically evaluate and correctly interpret (non-linear) regression models for correlated data and to implement the analysis in R. They will appreciate the various trade-offs between the different available methodologies and their software

	implementations for this model class and the extent (or lack) of theoretical guarantees for the corresponding estimates. They will also recognize the fundamental structural overlap between the different formulations of the basic problem as it appears from the perspectives of empirical risk minimization likelihood inference, Bayesian inference and Gaussian processes.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Scheipl
Language(s)	English
Additional information	None

Module: WP 22 Decision Theory

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 22.1 Decision Theory (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 22.2 Decision Theory (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The course develops concepts and paradigmatic ideas of decision theory as the theory of rational behavior under uncertainty. After introducing the fundamental notions (actions/decision functions, states, utility/loss/risk functions, randomization), the standard estimation and testing problems are embedded as special cases into the decision theoretic framework. Then fundamental decision principles (most notably admissibility) and classical decision criteria (including the Bayes and minimax criterion) are investigated and related to different types of uncertainty. Finally, an overview of modern developments in the area of decision making under ambiguity is given.
Learning outcomes	The students are familiar with the most important decision theoretic notions. They are able to utilize the generality of the framework for a deeper understanding and critical evaluation of statistical methods.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Augustin
Language(s)	English
Additional information	None

Module: WP 27 Teaching Statistics and Data Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 27.1 Didactical Tools in Statistics and Data Science	SoSe	15 h (1 SWS)	45 h	(2)
Seminar	WP 27.2 Teaching Project	SoSe	15 h (1 SWS)	105 h	(4)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	The module supports students giving a tutorial by some background on teaching in general and from mathematical didactics in particular. A special focus is first laid on methods to motivate students in tutorials to participate and learn actively. Secondly, tools to help students from other faculties to overcome reservations, and indeed often anxiety, with respect to mathematics and statistics are discussed. Finally, the exchange among the tutors is intensified by discussing their current teaching experiences.
Learning outcomes	Students giving a tutorial learn to reflect on their own teaching experiences. They have learned and practiced methods and tool to improve their teaching
Type of examination	Presentation or term paper
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Augustin
Language(s)	English
Additional information	None

Module: WP 28 Statistical Literacy

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 28.1 Statistical Literacy (Lecture)	SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 28.2 Statistical Literacy (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 1
Duration	The completion of the module takes 1 semester.
Content	This course reflects on the importance of statistical literacy and the communication abilities of statisticians for modern society. This ranges from basic communication skills about statistical terms like uncertainty or probability in the public over activities to increase statistical literacy in society to special techniques for the dissemination of research results.
Learning outcomes	The students are aware of the crucial importance of statistical literacy for a modern society. They are able to communicate and publish in a way understandable to non-statisticians, and they are familiar with techniques to increase statistical literacy in society.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Augustin
Language(s)	English
Additional information	None

Module: P 2 Supervised Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 2.1 Supervised Learning (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 2.2 Supervised Learning (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Mandatory module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected. In particular, a suitable background is needed on machine learning, basic programming (ideally in R or Python), matrix algebra, and basic optimization.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The course introduces the theoretical foundation of supervised machine learning as well as the most prominent methods in this field. It covers the basic principles of risk minimization and information-theoretic concepts such as entropy and Kullback-Leibler divergence. Furthermore, the curse of dimensionality is explained. The capacity of a learner, PAC learning, the no free lunch theorem, and regularization is covered in the first part. In the second part, different prominent learners such as linear and non-linear support vector machines, Gaussian processes and boosting are explained.
Learning outcomes	Students understand the foundations of risk minimization, information theory, learning theory and regularization. They are familiar with the inner workings of advanced machine learning approaches.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: P 4 Consulting

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	P 4.1 Introduction to Consulting	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	P 4.2 Consulting Project	WiSe and SoSe	15 h (1 SWS)	165 h	(6)
Seminar	P 4.3 Communication and Dissemination of Data Analyses	WiSe and SoSe	15 h (1 SWS)	75 h	(3)

For successful completion of the module, 12 ECTS credits have to be acquired. Class attendance averages about 3 contact hours. Including time for self-study, 360 hours have to be invested.

Module type	Mandatory module with mandatory modules
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	Especially for the second part of the module, it is strongly recommended to have attended the compulsory modules of the previous semester, in particular Statistical Modelling (P1) and Statistical Inference (P3).
Semester	Recommended semester: 2
Duration	The completion of the module takes 2 semesters.
Content	Students work on real practical problems with external collaboration partners. The project partners are either (applied) scientists or external domain experts from industry and business. The projects are provided to the students but can also be proposed by the students themselves. The projects need to fulfil specific requirements such as e.g. a) data are available, b) the question is statistically challenging enough, c) the major task is not solely on software implementation. All projects need the formal approval of the responsible lecturer.
Learning outcomes	The students have developed the necessary communication skills to interact with the project partners. They know how translate the natural language description of the problem into appropriate statistical terms and methods (and vice versa). They performed suitable analyses and

	communicated the correctly interpreted results of their analysis both verbally and in writing. They have also gained the necessary technical expertise to make their data analysis reproducible.
Type of examination	Presentation and term paper
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Scheipl
Language(s)	English
Additional information	None

Module: WP 1 Optimization

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 1.1 Optimization (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 1.2 Optimization (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected. In particular, a suitable background is needed on one- and multidimensional calculus, linear algebra and a programming language.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The course introduces the theoretical foundation of optimization as well as the most prominent methods in this field. It covers the taxonomy of optimization problems and other basic principles of optimization, considering univariate and multivariate problems and commonly used approaches to tackle these. This contains first- and second-order methods as well as stochastic approaches. The course further deals with constrained optimization problems, derivative-free methods as well as multi-criteria optimization.
Learning outcomes	Students understand how to describe and apply optimization problems and know how to solve these in univariate and multivariate settings, potentially with constraints or with multiple criteria.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 2 Preclinical and Clinical Studies

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 2.1 Preclinical and Clinical Studies (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 2.2 Preclinical and Clinical Studies (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The course addresses statistical issues arising in the drug development process. The first part introduces the main phases of the drug development process and then focuses on preclinical studies by covering basic principles of pharmacokinetics, pharmacodynamics and toxicology. The second part concentrates on the design, analysis and interpretation of clinical studies. It covers different randomization techniques, sample size calculation for binary and continuous outcomes and multiple testing issues arising in the analysis of clinical studies. It also introduces more advanced designs including for instance sequential, cross-over and stepped-wedge designs. The third part of the lecture covers more advanced topics including for instance Bayesian methods in the analysis of preclinical and clinical studies and important issues arising in the treatment of intercurrent events and missing values.
Learning outcomes	At the completion of the course, students understand the most important concepts and challenges in the design,

	analysis and interpretation of preclinical and clinical studies. They have a basic understanding of the most fundamental aspects of pharmacokinetic and pharmacodynamic modelling. In the design of clinical studies, they are able to choose appropriate statistical tools and methods for sample size calculation and randomization. They are familiar with more advanced designs, issues of multiple testing and strategies to address intercurrent events and missing values in clinical studies.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Boulesteix
Language(s)	English
Additional information	None

Module: WP 3 Complex Samples and Data Structures

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 3.1 Complex Samples and Data Structures (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 3.2 Complex Samples and Data Structures (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The sample survey is a widely-used tool for describing populations, investigating social phenomena, and informing policy decisions. This course considers the process of selecting a random sample from the target population, with an emphasis on practical aspects of various sample designs. The course will introduce students to the basic principles of sampling that are commonly used in large-scale surveys. The course will cover several sample designs, including simple random sampling, systematic sampling, stratified sampling, cluster sampling, and multistage sampling, among others. The course will also provide an introduction to key elements of weighting for unequal probabilities of selection, differential non-response, and non-coverage. The course is structured around the following topics: simple random sampling, frames and frame problems, cluster sampling, stratified sampling, multistage sampling, telephone sampling, and weighting and variance estimation.
Learning outcomes	By the end of the course students will know the key terminology used in designing complex samples. They will

	clearly understand the differences between various sampling designs and understand their advantages and disadvantages. Students will be able to assess how different sampling designs affect statistical analysis. Students will be able to apply appropriate variance estimation techniques to a variety of complex sample designs and evaluate the efficiency of those techniques. They will also have a clear understanding of the steps involved in designing complex samples in real-world settings.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kreuter
Language(s)	English
Additional information	None

Module: WP 4 Basic Concepts and Structures in Official Statistics, Dissemination and Privacy Protection

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 4.1 Basic Concepts and Structures in Official Statistics, Dissemination and Privacy Protection (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 4.2 Basic Concepts and Structures in Official Statistics, Dissemination and Privacy Protection (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	Official statistics lay the groundwork for evidence-based decision processes for governments. In this course, participants will get to know the basic concepts and principles of official statistics in Germany and the European Union, including the business production model and the European Statistical System as a whole. Furthermore, the implications of new methodologies in the Big Data context, Smart Statistics and modern dissemination principles are discussed. The high-quality standards within official statistics are detailed, with a special focus on the Code of Practice and privacy protection issues.
Learning outcomes	In this course, students will understand the basic structure and the fundamental questions of official statistics. They know how to approach statistical methodology and data

	with the high standards required by official statistics. This extends to critically reflecting data production processes and ethical standards in the context of data analysis.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Augustin
Language(s)	English
Additional information	The module plays an important role in the EMOS specialization.

Module: WP 5 Causal Inference

Programme	Master' Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 5.1 Causal Inference (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 5.2 Causal Inference (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module introduces into causal analysis, mainly form an econometric perspective. The specific situation of causal analysis is introduced, with an emphasis on counterfactuality and potential outcomes. Different aims oof causal analysis are identified, and inference methods specifically adopted to them are discussed.
Learning outcomes	Students understand the principled differences of specific designs and are able to apply and extend specific methods. They are aware of the power and limitations of methods and designs for producing causal conclusions.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 6 Survival Analysis

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 6.1 Survival Analysis (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 6.2 Survival Analysis (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and an introduction to machine learning.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	In this course different techniques for handling time-to-event data are presented. Such methods play an important role in different fields of application, particularly in biomedical applications (survival), but also sociology (e.g. length of marriage), industry (reliability, warranty) and production (predictive maintenance). The module begins with the introduction of basic quantities like hazard rates and survival functions (and their relationships) as well as different estimators for the distribution of event times under different types of censoring (left-, right-, and interval-censoring) and truncation (left- and right-truncation). In particular, different univariate, non-parametric techniques for right-censored and left-truncated data (life-table, Kaplan-Meier and Nelson-Aalen estimators) as well as parametric (accelerated failure time) and semi-parametric (Cox, piecewise exponential) models for the estimation of time-to-event outcomes are discussed. Students will also learn to deal with more advanced settings with recurrent events and competing risks. Additionally, the course will

	cover models for time-to-event outcomes on discrete time scales. Finally, some basic workflows for the application of machine learning techniques to time-to-event data will be covered.
Learning outcomes	Students will be able to identify the correct type of censoring and truncation present in different studies with time-to-event endpoints and choose an appropriate method for their analysis. In particular, students will be able to apply complex regression strategies to estimate baseline hazards as well as potentially time-varying effects of potentially time-dependent covariates. They will also be able to check the different assumptions of the models and modify models in order to relax these assumptions if necessary (in particular the proportional hazards assumption).
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 31 Advanced Research Methods in Applied Statistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 31.1 Discussion of Current Research in Applied Statistics	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 31.2 Research Project in Applied Statistics	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module focuses on a current specified research topic in applied statistics.
Learning outcomes	Students gain an in-depth insight into special research areas of applied statistics and practice dealing with scientific working methods. The ability to deal with current research literature as well as its presentation and discussion will be deepened.
Type of examination	Presentation and term paper
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Dean of Studies (Augustin)
Language(s)	English
Additional information	None

Module: WP 32 Current Research in Machine Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 32.1 Current Research in Machine Learning (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 32.2 Current Research in Machine Learning (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture provides a broad overview on currently relevant research methods from the fields of machine learning and deep learning. The exercise class will deepen the understanding of the machine learning concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students are familiar with selected methods of current machine learning research. They are aware of the current state of the art in the discussed fields and are able to understand and assess relevant research papers.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 33 Automated Machine Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 33.1 Automated Machine Learning (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 33.2 Automated Machine Learning (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory / specialization specifically recommended modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module addresses the challenge of designing well-performing machine learning pipelines, including their hyperparameters, architectures of deep neural networks and pre-processing. Students will learn how to use and design automated approaches for determining such machine learning efficiently. Some important concepts are hyperparameter optimization, where the hyperparameter settings of a given machine learning algorithm are optimized to achieve great performance on a given dataset, neural architecture search, where the architecture of a neural network is tuned for its predictive performance (or in addition inference time or model size) on a given dataset, AutoML optimizers, concerned with approaches such as Bayesian optimization, evolutionary algorithms, multi-fidelity optimization and gradient-based optimization, and Dynamic & Meta-Learning, where useful meta strategies for speeding up the learning itself or AutoML are learned across datasets.
Learning outcomes	The students are able to identify possible design decisions and procedures in the application of ML. They know how

	to evaluate the design decisions for AutoML systems and to implement efficient optimizers for AutoML problems, such as hyperparameter optimization and neural architecture search. Finally, they have learned to increase the efficiency of AutoML via a multitude of different approaches.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 34 Selected Topics of Machine Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 34.1 Selected Topics of Machine Learning (Lecture)	WiSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 34.2 Selected Topics of Machine Learning (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture provides an insight into new methods from the fields of machine learning and deep learning as well as procedures in established or new application areas. The exercise class will deepen the understanding of the machine learning concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students have an exemplary deeper insight into selected machine learning and deep learning methods and results of current research.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 35 Statistical Methods in Epidemiology

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 35.1 Statistical Methods in Epidemiology (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 35.2 Statistical Methods in Epidemiology (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The course covers the most important methodological issues in the design, analysis and interpretation of epidemiological studies. The first part introduces key concepts in the modelling of communicable and non-communicable disease including the prevalence and the incidence of a disease and effect measures to describe the association between an exposure and an outcome variable of interest. It also addresses challenges and biases arising in the analysis of observational studies and critically discusses how different study designs and statistical techniques can address measured and unmeasured confounding in epidemiological studies. The second part treats more advanced topics. These include for instance the most important concepts and methods of causal inference and Bayesian methods for the analysis of communicable and non-communicable disease.
Learning outcomes	Students understand the main challenges and pitfalls arising in the design, analysis and interpretation of epidemiological studies. They are familiar with different study

	design and statistical methods to address these challenges and are able to choose an appropriate design and method for a given research question of interest.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Boulesteix
Language(s)	English
Additional information	None

Module: WP 36 Advanced Methods in Biostatistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 36.1 Advanced Methods in Biostatistics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 36.2 Advanced Methods in Biostatistics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture introduces and discusses advanced concepts and methods in Biostatistics. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students are familiar with advanced concepts and methods in Biostatistics.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Boulesteix

Language(s)	English
Additional information	None

Module: WP 37 Selected Biostatistical Applications

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 37.1 Selected Biostatistical Applications (Lecture)	WiSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 37.2 Selected Biostatistical Applications (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture introduces and discusses selected biostatistical applications. The exercise class will deepen the understanding of the applications discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students are familiar with biostatistical applications and have a deeper understanding for the application of concepts and methods in Biostatistics.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Boulesteix
Language(s)	English
Additional information	None

Module: WP 38 Measurement and Modelling in Social Sciences

Programme	Master's Prorgramme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 38.1 Measurement and Modelling in Social Sciences (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 38.2 Measurement and Modelling in Social Sciences (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module is concerned with different types of latent structures and their statistical handling. First the classical testing theory as a framework to describe the operationalization/measurement of continuous latent traits is discussed and also utilized to derive corresponding reliability measures like Cronbachs alpha. Then, different generalizations are studied, including structural equation models and Rasch-type models from probabilistic testing theory. In the second part of the module, methods for handling incomplete data in regression models are investigated in more detail. Advanced frequentist and Bayesian correction methods for measurement error, misclassification, and missing data are developed. In this context also an introduction into the framework of partial identification is given.

Learning outcomes	The students are familiar with statistical methods for formalizing and handling latent structures. They are able to apply and to adjust the corresponding methods. They also obtain a critical understanding of the different models developed and advocated in the literature, including their underlying explicit and implicit assumptions and limitations.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Augustin
Language(s)	English
Additional information	None

Module: WP 39 Computational Social Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 39.1 Computational Social Science (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 39.2 Computational Social Science (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module gives an overview of recent computer-intensive statistical and machine-learning based methods developed for typical settings in social sciences. Typical examples include social network analysis, the analysis of unstructured process-based data and the efficient use of dynamic para data in online surveys.
Learning outcomes	The students have an overview of recent problems and methods in computational social sciences. They have gained a deeper exemplary insight in a specialized method, its potential, specific modelling requirement and limitations.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kreuter
Language(s)	English
Additional information	None

Module: WP 40 Selected Topics of Social Statistics and Social Data Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 40.1 Selected Topics of Social Statistics and Social Data Science (Lecture)	WiSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 40.2 Selected Topics of Social Statistics and Social Data Science (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture provides an insight into new statistical methods in Social Statistics and Social Data Science. Recent developments in in established or new application areas are discussed. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	At the completion of the course, students are familiar with selected methods and results of current research.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kreuter
Language(s)	English
Additional information	None

Module: WP 41 Nonparametric Econometrics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 41.1 Nonparametric Econometrics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 41.2 Nonparametric Econometrics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester as well as at least one of the basic courses of the specialization in econometrics (WP 5, WP 17).
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module provides an overview over classical and modern non- and semiparametric methods, especially in the context of economic theory.
Learning outcomes	Students gain an overview of the most fundamental nonparametric methods in econometrics. They are familiar with the specific construction principles of nonparametric methods. They know advantages and short comings of nonparametric methods in comparison to their parametric counterparts.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 42 Current Research in Econometrics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 42.1 Current Research in Econometrics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 42.2 Current Research in Econometrics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester as well as at least one of the basic courses of the specialization in econometrics (WP 5, WP 17).
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture provides a broad overview on currently relevant research methods from the fields of econometrics. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students are familiar with selected methods of current econometric research. They are aware of the current state of the art in the discussed fields and are able to understand and assess relevant research papers.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The succesful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 43 Advanced Applied Econometrics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 43.1 Advanced Applied Econometrics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 43.2 Advanced Applied Econometrics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester as well as at least one of the basic courses of the specialization in econometrics (WP 5, WP 17).
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module gives an exemplary insight into methods of applied econometrics by discussing prototypic case studies from econometric literature.
Learning outcomes	The students learn to bridge econometric theory and applications. They understand the formalization process of basic economic questions into methodical questions and they can judge the limiting character of compromises to make in this context.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 44 Advanced Statistical Modelling

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 44.1 Advanced Statistical Modelling (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 44.2 Advanced Statistical Modelling (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester as well as at least one of the basic courses of the specialization in methodology and modelling.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture provides a broad overview on currently relevant research methods in methodology and modelling. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students are familiar with selected methods of current research in methodology and modelling. They are aware of the current state of the art in the discussed fields and are able to understand and assess relevant research papers
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Küchenhoff
Language(s)	English
Additional information	None

Module: WP 45 Spatial Statistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 45.1 Spatial Statistics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 45.2 Spatial Statistics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester, in particular Statistical Modelling (P1) and Statistical Inference (P3).
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture covers the essential classes of spatial stochastic processes for the modelling of spatial phenomena: Gaussian processes, Markov random fields and spatial point processes. Explorative methods for spatial data will be discussed. The lecture also covers applications of spatial processes, e.g., Disease Mapping, Kriging, Image Analysis, geoadditive regression, and Cox processes.
Learning outcomes	The course provides necessary knowledge and skills for the analysis of spatial data. It creates a basic understanding of the difficulties involved and to important techniques to overcome them.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Schmid
Language(s)	English
Additional information	None

Module: WP 46 Selected Topics of Methodology and Modelling

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 46.1 Selected Topics of Methodology and Modelling (Lecture)	WiSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 46.2 Selected Topics of Methodology and Modelling (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester as well as at least one of the basic modules (WP 6, WP 21 and WP 22) of the specialization in methodology and modelling.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module gives an exemplary insight into a specific topic in the area of methodology and modelling. It discusses important aspects of the formalization and abstraction of a practical research question into the theoretical framework as well as of the appropriate back-interpretation into the subject matter context.
Learning outcomes	The students deepen their knowledge about modelling and formalization processes, in particular their impact on applied research. They reflect modelling processes and their limitations from an advanced scientific perspective.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Augustin
Language(s)	English
Additional information	None

Module: WP 47 Advanced Programming

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 47.1 Advanced Programming (Lecture)	WiSe	15 h (1 SWS)	105 h	(4)
Exercise	WP 47.2 Advanced Programming (Exercise Course)	WiSe	30 h (2 SWS)	30 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 3 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester; in particular intermediate programming proficiency in R is required.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This course teaches advanced applied programming concepts, specifically for R. This includes advanced parallelization and workflow management tools suitable for fully reproducible analyses using R on HPC systems or in virtual machines and containers and the creation and maintenance of R packages. The course also covers metaprogramming in R (quoting, calls, expressions, forced and lazy evaluation), functional programming, as well as specific more advanced programming principles and algorithmic patterns. Throughout the course, (collaborative) programming challenges allow students to practice their project management and programming skills and gather hands-on experience in the use of collaboration tools like issue trackers, project boards and wikis.
Learning outcomes	Students can develop and maintain well-documented, well-structured and computationally efficient R packages that implement complex data processing pipelines reproducibly and reliably. They are able to write and debug R code that makes use of "computing on the language" metaprogramming as well as parallelized or asynchronous code execution and functional programming and are familiar with

	modern collaboration tools for software development.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Scheipl
Language(s)	English
Additional information	None

Module: WP 48 Recent Advances in Theoretical Statistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 48.1 Recent Advances in Theoretical Statistics (Lecture)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 48.2 Recent Advances in Theoretical Statistics (Exercise Course)	WiSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester, in particular Statistical Inference (P3).
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The module gives an overview and deeper insights in selected recent developments in theoretical statistics. This covers for instance current trends in robust and nonparametric frequentist and Bayesian statistics, in statistical inference of dynamic processes or non-standard data structures and statistical consequences of trends in modern probability theory. The corresponding exercise classes discuss recent applications and implementations.
Learning outcomes	The students have an overview of ongoing research in theoretical statistics and are able to acquire and classify current methodological developments in that area.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Dean of Studies (currently: Augustin)
Language(s)	English
Additional information	None

Module: WP 49 Selected Topics of Statistical Computing

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 49.1 Selected Topics of Statistical Computing (Lecture)	WiSe and SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 49.2 Selected Topics of Statistical Computing (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester. In addition, intermediate programming proficiency in R is required.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	The lecture provides an insight into the computational complexity of different statistical methods and algorithms. It further deals with estimating/training these models and architectures on suitable hardware. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	Students are introduced to estimating/training complex models/architectures.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 50 Selected Topics of Programming

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 50.1 Selected Topics of Programming (Lecture)	WiSe and SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 50.2 Selected Topics of Programming (Exercise Course)	WiSe and SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semester and to have advanced knowledge and experience in programming software for data analysis.
Semester	Recommended semester: 2
Duration	The completion of the module takes 1 semester.
Content	This module provides students with additional courses to advance their understanding of data analysis related software. This includes extended programming knowledge, e.g. parallelization, advanced debugging, code profiling and optimization w.r.t. speed and memory efficiency and working on distributed systems, like high performance clusters etc., work with GPUs (especially in context of Machine Learning and Deep Learning) and domain specific programming knowledge, for example working with microarray data, signal processing, fMRI, Image Data and Natural Language processing, image segmentation and others. A further focus could lie in the programmatic generalization of reusable code in form of add-on packages for popular data analysis software like R or Python.
Learning outcomes	Students will acquire in depth knowledge within a specific programming language or a specific aspect within this

	language. Students will become experts in the respective field of programming, data analysis or software development.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 8 Advanced Machine Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 8.1 Advanced Machine Learning (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 8.2 Advanced Machine Learning (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters, in particular Supervised Learning (P2) and Optimization (WP1).
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The course directly builds on the "Supervised Learning" lecture and introduces advanced machine learning concepts for some selected topics that were not covered in the "Supervised Learning" lecture, such as imbalanced, multi-label or cost-sensitive classification, feature engineering, advanced hyperparameter tuning approaches, performance estimation and calibration techniques, uncertainty quantification, fairness, interpretability and other related concepts. The course will also touch extensions and recent developments for some ML algorithms (e.g., for trees, forests, boosting) as well as for advanced ensemble methods.
Learning outcomes	At the completion of this module, students will have a profound understanding of concepts and current trends in selected advanced machine learning topics that go beyond the basics.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 9 Applied Machine Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 9.1 Applied Machine Learning (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 9.2 Applied Machine Learning (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters, in particular Supervised Learning (P2) as well as modules on programming skills in R or Python. Sound theoretical knowledge of different methods of supervised learning such as principles of risk minimization, hyperparameter tuning and different learners such as random forests and SVMs are need. Furthermore, good programming skills in R or Python are expected.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	This course applies the theoretical concepts of the previous courses in machine learning to practical problems. The focus is (a) on the implementation of the previously learned methods with current tool kits and (b) on practical pitfalls and how to cope with them.
Learning outcomes	Students will have the practical skills to work on advanced practical problems of supervised machine learning through their gained experience in implementing analyses and through their sound understanding of practical pitfalls.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	None

Module: WP 11 Selected Topics of Biostatistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 11.1 Selected Topics of Biostatistics (Lecture)	SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 11.2 Selected Topics of Biostatistics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The lecture provides an insight into new statistical methods in Biostatistics and procedures in established or new application areas. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	At the completion of the course, students are familiar with selected methods and results of current research.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Boulesteix
Language(s)	English
Additional information	None

Module: WP 12 Analysis of High-dimensional Biological Data

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 12.1 Analysis of High-dimensional Biological Data (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 12.2 Analysis of High-dimensional Biological Data (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module gives an overview of analysis of high-dimensional data, in particular from a computational biology angle. First, classical methods like cluster and factor analysis are extended to cope with large biological data sets. In the second part, different computer-intensive methods are introduced that are able to handle the p>>n situations typical for genomic data. The range from adopted machine learning methods to certain ensembled methods directly developed for cell data.
Learning outcomes	The students have a systematic overview of different methods to analyze high dimensional data. They have a critical understanding of their power and their specific limitations.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Müller
Language(s)	English
Additional information	None

Module: WP 16 Advanced Methods in Social Statistics and Social Data Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 16.1 Advanced Methods in Social Statistics and Social Data Science (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 16.2 Advanced Methods in Social Statistics and Social Data Science (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The increasing availability of digital data sources has led to an explosion of new research and data collection avenues in social science and social statistics. This is paralleled by an increasing use of techniques from the field of machine learning to process unstructured and heterogenous digital data. This module reflects on current trends in social statistics and discusses advantages and limitations of state-of-the-art social data science methodology. Key aspects include questions of accountability, fairness and privacy in the context of automated processing of digital data sources.
Learning outcomes	At the completion of this module, students will have a profound understanding of current trends in social statistics and social data science. Students will learn how to critically reflect on the use of digital data sources and new

	processing avenues and will apply state-of-the-art methodology in practice.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kreuter
Language(s)	English
Additional information	None

Module: WP 19 Machine Learning in Econometrics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 19.1 Machine Learning in Econometrics (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 19.2 Machine Learning in Econometrics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and an introduction to machine learning.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The course will give an overview of modern machine learning techniques in econometrics. Special attention will be paid to methods that address complex nonstandard data structures arising from specified econometric questions, like paired comparison data.
Learning outcomes	Students have an overview of machine learning methods applied to econometric questions. They are aware of specific methods for certain complex econometric data structures, their specific technical requirements and their limitations.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 20 Selected Topics of Econometrics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 20.1 Selected Topics of Econometrics (Lecture)	SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 20.2 Selected Topics of Econometrics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module focuses on specific research questions of current econometric research literature.
Learning outcomes	Students gain exemplary insights in current research. The understand the interplay between specific econometric questions and corresponding methodological developments.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Wilhelm
Language(s)	English

Additional information	None

Module: WP 23 Methodological Discourses in Statistics and Data Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 23.1 Methodological Discourses in Statistics and Data Science (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 23.2 Methodological Discourses in Statistics and Data Science (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical inference and machine learning.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module introduces current and classical methodological discourses in statistics, machine learning and data science. First different conceptualizations and formalizations of uncertainty are discussed. Then different data analytical and inferential paradigms are investigated.
Learning outcomes	The students are familiar with the major paradigmatic positions towards learning from data and are able to discuss and evaluate current methodological developments against this background.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Dean of Studies (currently: Augustin)
Language(s)	English
Additional information	None

Module: WP 24 Design of Experiments

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 24.1 Design of Experiments (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 24.2 Design of Experiments (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module introduces the main principles of design of experiments. It starts with simple experiments including randomization and the subsequent analysis of the data using analysis of variance (ANOVA). The content then proceeds towards more complex designs like block-design, factorial design and fractional designs. Repeated measurements as well as latin squares are discussed as well. The module continues with a general discussion on causality and links ideas from design of experiments to settings with observational data. Wherever possible, the material of the course is accompanied by small practicals.
Learning outcomes	The students know why and when experiments are required and how these should be designed. They are aware of classical analysis tools and can extend the ideas to questions of causality.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kauermann
Language(s)	English
Additional information	None

Module: WP 25 Advanced Mathematical Concepts for Statistics and Data Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 25.1 Advanced Mathematical Concepts for Statistics and Data Science (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 25.2 Advanced Mathematical Concepts for Statistics and Data Science (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, it is strongly recommended to have a strong background in calculus and linear algebra, including basic proof techniques.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The course gives a deeper exemplary insight into mathematical concepts in statistics and data science. In particular, methods at the intersection of classical mathematical subdisciplines (like measure theory, order and lattice theory, numerical optimization, dynamical systems, functional analysis, and financial mathematics) and statistics and data science are investigated.
Learning outcomes	The students deepen their mathematical knowledge in neighboring fields. They understand the mathematical background behind certain modern statistical methods.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Dean of Studies (currently Augustin)
Language(s)	English
Additional information	None

Module: WP 26 Stochastic Processes

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 26.1 Stochastic Processes (Lecture)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	WP 26.2 Stochastic Processes (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 6 ECTS credits have to be acquired. Class attendance averages about 4 contact hours. Including time for self-study, 180 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and calculus.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The lecture gives a short introduction into the theory of stochastic processes. Following this, different classes of stochastic processes, their applications and methods for statistical inference are discussed. The topics of the course include, but are not limited to, Markov chains, Markov processes, semi-Markov processes, and renewal processes. The exercises will deepen the theoretical concepts and students will be enabled to apply stochastic processes.
Learning outcomes	At the end of the course, the students will have a basic understanding of the theory of stochastic processes and their application to correlated data, especially data correlated in time.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Schmid
Language(s)	English
Additional information	None

Module: WP 29 Selected Topics of Applied Statistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 29.1 Selected Topics of Applied Statistics (Lecture)	SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 29.2 Selected Topics of Applied Statistics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and on machine learning.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The lecture provides an insight into new statistical methods and procedures in established or new application areas. The exercise class will deepen the understanding of the concepts discussed in the lecture and enable students to apply the methods and techniques learned in the lecture.
Learning outcomes	At the end of the course, students have an exemplary insight into selected methods and results of current research.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Dean of Studies (currently Augustin)
Language(s)	English
Additional information	None

Module: WP 30 Selected Software for Applied Statistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Lecture	WP 30.1 Selected Software for Applied Statistics (Lecture)	SoSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 30.2 Selected Software for Applied Statistics (Exercise Course)	SoSe	15 h (1 SWS)	45 h	(2)

For successful completion of the module, 3 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 90 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	The requirements of the eligibility process for the master's degree in statistics and data science are expected; in particular, a suitable background is needed on concepts of statistical modelling and machine learning. Moreover, basic proficiency with statistical software is required.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The lecture provides insights into state of the art software packages for statistical applications from methodological, software-engineering and applied perspectives. The exercise class will use case studies and programming tasks to deepen the understanding gained through the lecture and enable students to apply complex software for challenging data analyses.
Learning outcomes	Students become proficient in the implementation details, the user interface and the scope of application of state of the art software packages for statistical applications and obtain basic programming proficiency in a relevant programming language.
Type of examination	Written exam or oral examination or term paper or exercise portfolio

Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Scheipl
Language(s)	English
Additional information	None

Module: WP 51 Advanced Research Methods in Theoretical Statistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 51.1 Discussion of Current Research in Theoretical Statistics	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 51.2 Research Project in Theoretical Statistics	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	In the seminar current research papers in theoretical statistics are discussed. Their basic methodical context, their specific methodological contributions and impact and the requirements and limitations of the underlying methods are worked out and mutually compared.
Learning outcomes	Students gain an in-depth insight into special research areas of theoretical statistics. They deepen their practice in scientific working methods by dealing with current research literature as well as its presentation and discussion.
Type of examination	Presentation and term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Nagler
Language(s)	English
Additional information	None

Module: WP 52 Advanced Research Methods in Machine Learning

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 52.1 Discussion of Current Research in Machine Learning	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 52.2 Research Project in Machine Learning	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters, in particular Supervised Learning (P2). Moreover, the knowledge from the basic modules in the machine learning specialization (WP 1 and W7) is needed.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module provides an insight into current advanced methods for conducting research in the fields of machine learning and deep learning.
Learning outcomes	Students gain an in-depth insight into special research areas of machine learning and deep learning. They deepen their practice in scientific working methods by dealing with current research literature as well as its presentation and discussion.
Type of examination	Written exam or oral examination or term paper or exercise portfolio
Type of assessment	The successful completion of the module will be graded.

Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Bischl
Language(s)	English
Additional information	For the attendance of a seminar a registration at the seminar distribution platform in the LSF system is needed.

Module: WP 53 Advanced Research Methods in Biostatistics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 53.1 Discussion of Current Research in Biostatistics	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 53.2 Research Project in Biostatistics	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters. Moreover, knowledge from the basic module in the biostatistics specialization (WP 2) is needed, and it is highly recommended to have attended at least one further module from WP 6, WP 10 to WP 13, WP 21 and WP 35 to WP 37.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module provides an insight into current advanced methods for conducting research in the field of biostatistics.
Learning outcomes	Students gain an in-depth insight into special research areas of biostatistics. They deepen their practice in scientific working methods by dealing with current research literature as well as its presentation and discussion.
Type of examination	Presentation and term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Boulesteix
Language(s)	English
Additional information	None

Module: WP 54 Advanced Research Methods in Social Statistics and Social Data Science

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 54.1 Discussion of Current Research in Social Statistics and Social Data Science	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 54.2 Research Project in Social Statistics and Social Data Science	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters and two of the basic modules (WP 3, WP 14 and WP 38) in the social statistics and social data science specialization.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module provides an insight into current advanced methods for conducting research in the field of social statistics and social data science.
Learning outcomes	Students gain an in-depth insight into special research areas of social statistics and social data science. They deepen their practice in scientific working methods by dealing with current research literature as well as its presentation and discussion.
Type of examination	Presentation and term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Kreuter
Language(s)	English
Additional information	None

Module: WP 55 Advanced Research Methods in Econometrics

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 55.1 Discussion of Current Research in Econometrics	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 55.2 Research Project in Econometrics	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters, the two basic modules (WP and WP 17) of the econometrics specialization and WP 19 or WP 41.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module provides an insight into current advanced methods for conducting research in the field of econometrics.
Learning outcomes	Students gain an in-depth insight into special research areas of econometrics. They deepen their practice in scientific working methods by dealing with current research literature as well as its presentation and discussion.
Type of examination	Presentation and term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.

Responsible contact	Wilhelm
Language(s)	English
Additional information	None

Module: WP 56 Advanced Research Methods in Methodology and Modelling

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Seminar	WP 56.1 Discussion of Current Research in Methodology and Modelling	WiSe and SoSe	15 h (1 SWS)	75 h	(3)
Seminar	WP 56.2 Research Project in Methodology and Modelling	WiSe and SoSe	15 h (1 SWS)	165 h	(6)

For successful completion of the module, 9 ECTS credits have to be acquired. Class attendance averages about 2 contact hours. Including time for self-study, 270 hours have to be invested.

Module type	Compulsory elective module with mandatory courses
Usability of the module in other programmes	None
Elective guidelines	The module can be chosen in compliance with the following rules: S. Appendix I
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters and two of the basic modules (WP 6, WP 21 and WP 22) in the methodology and modelling specialisation.
Semester	Recommended semester: 3
Duration	The completion of the module takes 1 semester.
Content	The module provides an insight into current advanced methods for conducting research in the field of statistical methodology or statistical modelling.
Learning outcomes	Students gain an in-depth insight into special research areas of statistical methodology or statistical modelling. They deepen their practice in scientific working methods by dealing with current research literature as well as its presentation and discussion.
Type of examination	Presentation and term paper
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and

	possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Schmid
Language(s)	English
Additional information	None

Module: P 5 Final Module

Programme	Master's Programme: Statistics and Data Science (Master of Science, M.Sc.)

Related module parts

Course type	Course (mandatory)	Rotation	Contact hours	Self-study hours	ECTS
Master's Thesis	P 5.1 Master's Thesis	WiSe und SoSe	-	840 h	(28)
Disputation	P 5.2 Disputation	WiSe und SoSe	-	60 h	(2)

For successful completion of the module, 30 ECTS credits have to be acquired. Class attendance averages about 0 Contact hours. Including time for self-study, 900 Hours have to be invested.

Module type	Mandatory module
Usability of the module in other programmes	None
Elective guidelines	None
Entry requirements	It is strongly recommended to have attended the compulsory modules of the previous semesters, in particular Statistical Modelling (P1), Supervised Learning (P2) and Statistical Inference (P3)
Semester	Recommended semester: 4
Duration	The completion of the module takes 1 semester.
Content	The module includes an independently written thesis and its defense. Master's thesis: In a supervised but independently prepared thesis, a topic from statistics and data science is explored according to scientific principles. The master's thesis serves as proof of the ability to practically work on a scientific project with statistical problems. Disputation: During an oral examination, the master's thesis is defended, and an academic discussion is held on the topic of the thesis.
Learning outcomes	Students demonstrate the ability to independently complete and present a scientific project in Statistics and Data Science.

Type of examination	Master's thesis and disputation
Type of assessment	The successful completion of the module will be graded.
Requirements for the gain of ECTS credits	ECTS credits will be granted when the module examination (or the examination of relevant mandatory and possibly compulsory elective module parts) has/have been completed successfully.
Responsible contact	Schmid
Language(s)	English
Additional information	Grades of master thesis and disputations are being weighted in the ratio 25 to 5.

Appendix I: Rules for the choice of compulsory elective modules

With regard to the compulsory elective areas "Machine Learning", "Biostatistics", "Social Statistics and Data Science", "Econometrics" and "Methodology and Modelling", exactly one compulsory elective area must be chosen.

For this purpose, elective modules amounting to a total of 51 ECTS credits each are to be selected from the elective modules WP 1 to WP 56, namely

1. for compulsory elective area "Machine Learning"
- the compulsory elective modules WP 1, WP 7 and WP 52,
- from the compulsory elective modules WP 8, WP 9 and WP 32 to WP 34 compulsory elective modules amounting to at least 12 ECTS credits and
- from the compulsory elective modules WP 1 to WP 51 to achieve the 51 ECTS points per compulsory elective area, further compulsory elective modules amounting to a maximum of 18 ECTS points,

2. for compulsory elective area "Biostatistics"
- the compulsory elective modules WP 2 and WP 53,
- from the compulsory elective modules WP 10 to WP 13 and WP 35 to WP 37 compulsory elective modules in the amount of 12 ECTS credits,
- from the compulsory elective modules WP 6, WP 10 to WP 13, WP 21 and WP 35 to WP 37 further compulsory elective modules amounting to at least 6 ECTS credits and
- from the compulsory elective modules WP 1 to WP 51 to achieve the 51 ECTS points per compulsory elective area, further compulsory elective modules amounting to a maximum of 18 ECTS points,

3. for compulsory elective area "Social Statistics and Social Data Science"
- the compulsory elective module WP 54,
- two compulsory elective modules from the compulsory elective modules WP 3, WP 14 and WP 38,
- from the compulsory elective modules WP 3 to WP 6, WP 14 to WP 16, WP 21, WP 22 and WP 38 to WP 40 further compulsory elective modules amounting to at least 12 ECTS credits and
- from the compulsory elective modules WP 1 to WP 51 to achieve the 51 ECTS points per compulsory elective area, further compulsory elective modules amounting to a maximum of 18 ECTS points,

4. for compulsory elective area "Econometrics"
- the compulsory elective modules WP 5, WP 17, (WP 19 or WP 41) and WP 55,
- from the compulsory elective modules WP 4, WP 6, WP 15, WP 18 to WP 22, WP 38 and WP 41 to WP 43 further compulsory elective modules amounting to at least 6 ECTS credits and
- from the compulsory elective modules WP 1 to WP 51 to achieve the 51 ECTS points per compulsory elective area, further compulsory elective modules amounting to a maximum of 18 ECTS points,

5. for compulsory elective area "Methodology and Modelling"
- the compulsory elective module WP 56,
- from the compulsory elective modules WP 6, WP 21 and WP 22 two compulsory elective modules,
- from the compulsory elective modules WP 6, WP 21 to WP 26, WP 38 and WP 44 to WP 46 further compulsory elective modules amounting to at least 12 ECTS credits and

- from the compulsory elective modules WP 1 to WP 51 to achieve the 51 ECTS points per compulsory elective area, further compulsory elective modules amounting to a maximum of 18 ECTS points.

In the 1st semester elective modules with a total of 12 ECTS credits, in the 2nd semester elective modules with a total of 18 ECTS credits and in the 3rd semester elective modules with a total of 21 ECTS credits are to be chosen.