Georg-August-Universität
Göttingen

Directory of Modules

zu der Prüfungs- und Studienordnung für den konsekutiven Master-Studiengang "Angewandte Data Science" (Amtliche Mitteilungen I 17/2022 S. 222)

This is a translation of the directory of modules as promulgated in Official Bulletin II No. 04, p. 2364, dated April 27, 2022. Only those regulations published by the Georg-August-Universität Göttingen in its Official Bulletins are legally binding. Any claims to rights or titles resulting from the English translation of these regulations are expressly excluded.

Modules

Index by areas of study

I. Master's programme „Applied Data Science"

A total of 120 C have to be successfully completed according to the following regulations.

1. Core Curriculum (49 C)

A total of 49 C have to be successfully completed according to the following regulations.

a. Fundamentals of Data Science

The following six modules of 38 C in total have to be successfully completed.

Provided that students have prior knowledge of the fundamentals of data science, corresponding modules with a total maximum of 38 C are to be replaced by modules with at least the same extent according to No. 2. The mentor decides on this according to principles to be formulated by the examination board. Modules that have already been completed in the Bachelor's programme cannot be taken again.

b. Statistical methods of Data Science

One of the following modules of 6 C has to be successfully completed:

c. Computer Science methods of Data Science

One of the following modules of 5 C has to be successfully completed:

2. Professionalisation Section (41 C)

A total of at least 41 C have to be successfully completed according to the following regulations. Modules already completed in the Bachelor's programme cannot be considered again; modules completed according to No. 1 will not be considered again.

a. Elective courses Data Science (5 C)

At least one module of 5 C has to be successfully completed from letters aa to dd:

aa. Computer Science

bb. Statistics

cc. Mathematics

Modules of the following cycles of the mathematical teaching unit can be completed:

- Optimisation
- Inverse problems
- Image and geometry processing
- Scientific computing/applied mathematics

- Applied and mathematical stochastics
- Statistical modelling and inference
- Multivariate statistics
- Statistical foundations of data science

Additionally, the following modules can be chosen:

dd. Practical courses and seminars

b. Application domain (18 C)

In one of the following application domains modules of at least 18 C in total have to be successfully completed according to the regulations under No. II to V: “Computational Neuroscience”, “Bioinformatics”, "Medical Data Science", "Digital Humanities".

c. Key competencies (18 C)

A total of at least 18 C have to be successfully completed according to the following regulations.

aa. Job-related competencies

One of the following modules of 12 C has to be successfully completed:

bb. Interdisciplinary competencies

Modules amounting to at least 6 C (maximum 9 C) from the university-wide module directory for key competencies or the examination regulations for study programmes offered by the Central Institution for Languages and Key Qualifications (ZESS) must be taken. The examination board decides on further selectable modules, which are to be announced in an appropriate manner.

d. Prior knowledge in the Professionalisation Section

Students who have prior knowledge which largely corresponds to obligatory modules according to letter b are not required to complete these modules; in the case of an application domain, they are to be replaced by other modules of the application domain of comparable extent. The mentor decides on this according to principles to be formulated by the examination board. Modules that have already been completed in the Bachelor's programme cannot be taken again.

3. Further modules

Further modules according to No. 1 and 2 have to be successfully completed until at least 90 C have been earned in the core curriculum and the professionalisation section combined.

4. Master’s thesis

The following module of 30 C has to be successfully completed:

II. Application domain „Computational Neuroscience“

A total of at least 18 C have to be successfully completed according to the following regulations.

1. Fundamentals

The following three modules of 9 C in total have to be successfully completed:

2. Elective courses

A total of at least 9 C have to be successfully completed, among them at least one seminar.

III. Application domain „Bioinformatics“

A total of at least 18 C have to be successfully completed according to the following regulations.

1. Biological fundamentals

Two of the following modules of at least 6 C in total have to be successfully completed:

2. Elective courses Bioinformatics

A total of at least 12 C have to be successfully completed:

IV. Application domain „Medical Data Science“

A total of at least 18 C have to be successfully completed according to the following regulations.

1. Fundamentals of Medical Data Science

At least one module of at least 6 C in total has to be successfully completed:

2. Elective courses Medical Data Science

A total of at least 6 C have to be successfully completed:

V. Application domain „Digital Humanities“

A total of at least 18 C have to be successfully completed according to No. 1 and 2.

1. Elective module

The following module is recommended:

2. Elective courses

VI. Connector Courses

VII. Forms of examination

If module descriptions are published in English in this module directory, the forms of examination stated correspond to the following German translations:

- Oral exam = mündliche Prüfung [§ 15 Abs. 8 APO]
- Written exam = Klausur [§ 15 Abs. 9 APO]
- Term paper = Hausarbeit [§ 15 Abs. 11 APO]
- Presentation = Präsentation [§ 15 Abs. 12 APO]
- Presentation with written elaboration/report = Präsentation mit schriftlicher Ausarbeitung [§ 15 Abs. 12 APO]
- Practical examination = praktische Prüfung [§ 15 Abs. 13 APO]
- Internship report = Praktikumsbericht [§ 10 Abs. 2 PStO]

APO = Allgemeinen Prüfungsordnung für Bachelor- und Master-Studiengänge sowie sonstige Studienangebote an der Universität Göttingen

PStO = Prüfungs- und Studienordnung für den konsekutiven Master-Studiengang "Angewandte Data Science"

Georg-August-Universität Göttingen Module B.Bio.113: Applied bioinformatics	10 C 7 WLH
Learning outcome, core skills: After passing the module the students will understand the structure of most databases in bioscientific research and be able to critically assess their content. They will learn to structure biological data and transfer the data to a database scheme. Furthermore the students learn the application of bioinformatical methods in particular on sequence data, biological networks and expression data.	**Workload:** Attendance time: 98 h Self-study time: 202 h
Course: Einführung in die angewandte Bioinformatik (Lecture)	4 WLH
Examination: Written examination (90 minutes) **Examination prerequisites:** regular participation in the practical training and successful completion of three exercises **Examination requirements:** The students should know suitable sources of biomedical information available in the internet. They should be able to design and explain simple database schemes. The students should be familiar with measurements for critical assessment of bioinformatical methods; different methods for sequence comparison; reconstruction of phylogenetic trees; application of concepts from information theory on the analysis of sequence data. The students should be able to describe basic characteristics and graph theoretical representations of biological networks and apply these concepts to data analysis.	10 C
Course: Internet-basierte Bioinformatik (Exercise)	3 WLH

Admission requirements: BSc Biology: at least 40 C from the first study period	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Tim Beißbarth
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 5
Maximum number of students: 100	

Georg-August-Universität Göttingen **Module B.Inf.1213: Quantum computing**	5 C 3 WLH

Learning outcome, core skills:	**Workload:**
Es werden die Grundlage des Quantencomputings gelegt, so dass die Teilnehmerinnen und Teilnehmer im Anschluss dessen grundlegende Prinzipien im Vergleich zum klassischen Rechnen verstanden haben. Dies geschieht vermöge der Vermittlung grundlegender Algorithmen, wie Deutschs Algorithmus, Grovers Algorithmus, der Quanten-Fouriertransformation und Shors Algorithmus. Das geht nicht ohne ein Verständnis von Quantenregistern und Quantenschaltkreisen.	Attendance time: 42 h Self-study time: 108 h

Course: Quantencomputing (Lecture, Exercise)	3 WLH
Examination: Oral examinationMündliche Prüfung oder mündliche online Prüfung (ca. 20 min) (approx. 20 minutes) **Examination requirements:** Quantenregister; Quantenschaltkreise; Deutschs Algorithmus; Grovers Algorithmus; Quanten-Fouriertransformation; Shors Algorithmus; Vergleich Quantencomputing und klassisches Rechnen.	5 C

Admission requirements: Grundlagen der Analysis, der Lineare Algebra und der Theoretischen Informatik	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Stephan Waack
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 6
Maximum number of students: 50	

Georg-August-Universität Göttingen Module B.Inf.1231: Infrastructures of Data Science	6 C 4 WLH
Learning outcome, core skills: Upon completion the course, students • understand the basic functions of data science infrastructures and their significance. • understand basic data types and their specifics. • understand the most important technical infrastructures for storing and processing data locally and in the cloud as well as their advantages and disadvantages in relation to data science applications. • can apply the concept of the data lake to basic data science problems. • are able to apply the different steps of data pre-processing to selected data sets. • can identify the characteristics of time series and graph data and are able to recall the functions of DBMSs designed for their processing. • can present the basic tasks of data analysis platforms and can describe them using examples. • can apply methods and tools for the presentation and visualisation of data. • can model basic data science workflows and are able to transfer their knowledge to basic data science projects.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Infrastructures of Data Science (Lecture, Exercise) *Contents*: • Data types and their characteristics • Common functions of data science infrastructures • Storage, compute, and cloud infrastructures for data science • Concept of a data lake • Data pre-processing methods and selected tools • Time series and graph data, the respective DBMS, and query languages • Data analytics platforms • Data presentation and visualization • Data science workflows and selected infrastructure components	4 WLH
Examination: In-class, written exam (90 min) or oral exam (approx. 30 min.) **Examination prerequisites:** Students complete 50% of the homework exercises. **Examination requirements:** Through the examination students demonstrate that they are able to describe basic functions of (cloud-based) data science infrastructures as well as to specify and identify basic data types. Students can also prove their understanding of data lakes and can apply their knowledge of MapReduce and Hadoop in that particular context. They can analyse basic data pre-processing problems and sketch common solutions. Student can show that they understand time series and graph data as well as the corresponding DBMS and that they can present common tasks of data analysis platforms. Through the examination, students also demonstrate their ability to select appropriate methods for visualising data and show that they are able to create basic data science workflows.	6 C

Admission requirements: none	**Recommended previous knowledge:** Python and basic database knowledge (recommended, not mandatory)
Language: English	**Person responsible for module:** Hon.-Prof. Dr. Philipp Wieder
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 3 - 6; Master: 1 - 2
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module B.Inf.1236: Machine Learning**	6 C 4 WLH
Learning outcome, core skills: Students • learn concepts and techniques of machine learning and understand their advantages and disadvantages compared with alternative approaches • learn techniques of supervised learning for classification and regression • learn techniques of unsupervised learning for density estimation, dimensionality reduction and clustering • implement machine learning algorithms like linear regression, logistic regression, kernel methods, tree-based methods, neural networks, principal component analysis, k-means and Gaussian mixture models • solve practical data science problems using machine learning methods	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Machine Learning (Lecture) Bishop: Pattern recognition and machine learning. https://cs.ugoe.de/prml	2 WLH
Examination: Written examination (90 minutes) **Examination prerequisites:** B.Inf.1236.Ex: At least 50% of homework exercises solved. **Examination requirements:** Knowledge of the working principles, advantages and disadvantages of the machine learning methods covered in the lecture	6 C
Course: Machine Learning - Exercise (Exercise)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** Knowledge of basic linear algebra and probability
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4
Maximum number of students: 100	

Georg-August-Universität Göttingen **Module B.Inf.1237: Deep Learning**	6 C 4 WLH

Learning outcome, core skills: Students • learn concepts and techniques of deep learning and understand their advantages and disadvantages compared to alternative approaches • learn to solve practical data science problems using deep learning • implement deep learning techniques like multi-layer perceptrons, convolutional neural nerworks, recurrent neural networks, deep reinforcement learning • learn techniques for optimization and regularization of deep neural networks	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Deep Learning (Lecture) Goodfellow, Bengio, Courville: Deep Learning. https://www.deeplearningbook.org Bishop: Pattern Recognition and Machine Learning. https://cs.ugoe.de/prml	2 WLH
Examination: Written examination (90 minutes) **Examination prerequisites:** B.Inf.1237.Ex: At least 50% of homework exercises solved. **Examination requirements:** Knowledge of basic deep learning techniques, their advantages and disadvantages and approaches to optimization and regularization. Ability to implement these techniques.	6 C

Course: Deep Learning - Exercise (Exercise)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of linear algebra and probability Completion of B.Inf.1236 Machine Learning or equivalent
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 5
Maximum number of students: 100	

Georg-August-Universität Göttingen Module B.Inf.1240: Visualization	5 C 3 WLH
Learning outcome, core skills: Knowledge of • the potentials and limitations of data visualization • the fundamentals of visual perception and cognition and their implications for data visualization. Students can apply these to the design of visualizations and detect manipulative design choices • a broad variety of techniques for visual representation of data, including abstract and high-dimensional data. Students can select appropriate methods on new problems • integration of visualization into the data analysis process, algorithmic generation and interactive methods	**Workload:** Attendance time: 42 h Self-study time: 108 h

Course: Visualization (Lecture, Exercise)	3 WLH
Examination: Practical project (2-3 weeks) with presentation and questions during oral exam in groups (approx. 20 minutes per examinee). **Examination prerequisites:** At least 50% of homework exercises solved. **Examination requirements:** Knowledge of potentials and limitations of data visualization, fundamentals of visual perception and their implications for good design choices, techniques for visual representation and how to use them.	5 C

Admission requirements: none	**Recommended previous knowledge:** Basic linear algebra and programming skills
Language: English	**Person responsible for module:** Prof. Dr. Bernhard Schmitzer
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 6
Maximum number of students: 50	

Georg-August-Universität Göttingen Module B.Inf.1241: Computational Optimal Transport	6 C 4 WLH
Learning outcome, core skills: Knowledge of • the fundamental notions of optimal transport, and its strengths and limitations as a data analysis tool • the discrete Kantorovich formulation, its convex duality, and Wasserstein distances • classical numerical algorithms, entropic regularization, and their scopes of applicability • examples for data analysis applications. Students can transfer these to new potential applications	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Computational Optimal Transport (Lecture, Exercise)	4 WLH
Examination: Written exam (90 minutes) or oral exam (approx. 20 minutes) **Examination prerequisites:** At least 50% of homework exercises solved. **Examination requirements:** Knowledge of Kantorovich duality, Wasserstein distances, standard algorithms and implications for data analysis applications.	6 C

Admission requirements: none	**Recommended previous knowledge:** B.Mat.2310: Optimierung, analysis, linear algebra, programming skills
Language: English	**Person responsible for module:** Prof. Dr. Bernhard Schmitzer
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4 - 6
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module B.Inf.1242: Streaming Algorithms**	5 C 3 WLH

Learning outcome, core skills: After the successful completion of the module, the students should have a good understanding of the data stream model and its applications in practical scenarios (related, for instance, to the processing of big-data). We will present a series of algorithmic problems and their solutions in the streaming model, such as: finding frequent items, counting distinct elements, sketching, analysis of geometric streams, graph streams, text streams, communication complexity and lower bounds. On each specific topic, the lecture will start from a relatively low level (and cover also basic algorithms for arrays, graphs, strings, etc.). Basic references are the lecture Data Stream Algorithms by Amit Chakrabarti from University of Dartmouth (USA), and the Data Stream Algorithms Lecture Notes from a series of lectures by S. Muthu Muthukrishnan from the 2009 McGill (Barbados) Workshop on Computational Complexity (both available online).	**Workload:** Attendance time: 42 h Self-study time: 108 h

Course: Streaming Algorithms (Exercise)	1 WLH

Course: Streaming Algorithms (Lecture)	2 WLH
Examination: Oral examination (approx. 30 minutes)	5 C

Examination requirements: Oral presentation of a theoretical subject from the lecture and a sketch solution to an algorithmic problem related to the covered topics.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Florin Manea
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 20	

Georg-August-Universität Göttingen Module B.Inf.1243: Algorithms for Data Science	5 C 4 WLH

Learning outcome, core skills: After the successful completion of the module, the students should have a good understanding of fundamental algorithmic-approaches and -tools used in the area of data science. This lecture will approach topics related to: processing of fundamental data types and structures, such as numeric and textual data, graphs, spatial data, etc.; measuring the similarity of data; clustering; pattern matching, recognition, and mining; etc. The lecture will start from a relatively low level (and cover also basic algorithms for graphs, strings, etc.). The lecture will be loosely based on the two following two textbooks. Avrim Blum, John Hopcroft, and Ravi Kannan. Foundations of Data Science, 2018. URL:https://www.cs.cornell.edu/jeh/book.pdf. Charu C. Aggarwal. Data Mining: The Textbook, Springer, May 2015	**Workload:** Attendance time: 56 h Self-study time: 94 h

Course: Algorithms for Data Science (Exercise)	2 WLH

Course: Algorithms for Data Science (Lecture)	2 WLH
Examination: Oral Exam (approx. 30 min.) or Written Exam (120 min.)	5 C

Examination requirements: Oral presentation of a theoretical subject from the lecture and a sketch solution to an algorithmic problem related to the covered topics.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Florin Manea
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module B.Inf.1244: Data Management for Data Science**	5 C 4 WLH
Learning outcome, core skills: The module provides the fundamental conceptual, systemic and application-related aspects of the sustainable utilization of data from its creation and publication to its sustainable storage. Organized handling of data includes the processes of archiving and re-using data. This covers the strategic planning of research projects (research data management), the management of the technical foundations and the recording, organization, and linking of metadata. The participants will learn approaches to handle big data, including all facets of heterogenous or fast streaming data. We will also work on the concepts of (web) APIs in order to empower the participants to collect and combine their own data sets. The latter requires an understanding of standard processes such as Extract-Transform-Load (ETL). Data integration and interoperability of different data sources is the central challenge. The learned concepts will be tested and applied using advanced solutions. We will investigate the current market of data management tools, warehouse solutions or data processing platforms. The students develop the ability to think in systems and processes. The students are able to transfer their acquired knowledge and skills for problem solving to new areas of responsibility, to work together in groups and to work on new issues together.	**Workload:** Attendance time: 56 h Self-study time: 94 h
Course: Data Management for Data Science (Lecture, Exercise) *Contents*: • Data management processes in the context of the data life cycle • Tools for data management • Provision of data for data science processes • Data quality and data security • Data handling in the context of IoT • ETL/ELT processes • Stream & batch processing • Read-only-data structures • Data Lakes vs Data Warehouse • Event-driven data architectures	4 WLH
Examination: Written examination (120 minutes) **Examination requirements:** • Describing the data lifecycle • Understanding different approaches for data archiving • Explaining the structure, functionality and use of practice-relevant data management, storage and archiving systems • Understanding the ETL/ELT processes for data handling • Describing the concepts of data warehousing and data lakes • Describing the concepts and challenges for Big Data and data at scale • Understanding the read only data store architecture	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Sven Bingert
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module B.Inf.1246: Software Engineering for Data Science**	5 C 3 WLH

Learning outcome, core skills:
The students acquire the following competences in the areas of software engineering and engineering AI-enabled systems:

Part I: Software Engineering:

The studens

- know definition and tasks of software engineering
- know what a software project is and which persons and roles are involved in software projects.
- know and can assess different software engineering process models. The assessment is based on purposes as well as advantages and disadvantages of the models.
- know the principles of the development phases requirements engineering, design, implementation and quality assurance.
- can assess and apply basic techniques for requirements engineering, design and quality assurance.

Part II: Engineering AI-Enabled Systems

The students

- know principles and can assess methods of engineering processes for AI-enabled systems.
- know, assess and can apply engineering methods for engineering AI-enabled systems. Engineering methods may cover requirements engineering, design, architecture and operations.
- know and can assess the principles of responsible AI engineering. This includes knowledge about the aspects provenance, versioning, reproducibility, safety, security and privacy, fairness, interpretability and explainability, as well as transparency and trust.

Workload:
Attendance time:
42 h
Self-study time:
108 h

Course: Software Engineering for Data Science (Lecture, Exercise) — 3 WLH

Contents:
The lecture will cover topics from the following materials:

- Ian Sommerville. 2015. Software Engineering, Global Edition. Pearson Education.
- Christian Kästner, Eunsuk Kang. 2020. Teaching software engineering for AI-enabled systems. CSE-SEET '20: Proceedings of the ACM/IEEE 42nd International Conference on Software Engineering: Software Engineering Education and Training.
- Geoff Hulten. 2019. Building Intelligent Systems: A Guide to Machine Learning, Engineering. Apress.
- Jeff Smith. 2018. Machine Learning Systems: Designs that Scale. Manning Publications Co.

Examination: Written Exam (90 min.) or Oral Exam (approx. 20 min.) — 5 C

Examination prerequisites: Develop and present the solution of one exercise (presentation and report).	

Examination requirements: Software engineering definition, software projects, software processes, requirements engineering, design, implementation, quality assurance, engineering processes for AI-enabled systems, responsible AI engineering.	

Admission requirements: none	**Recommended previous knowledge:** B.Inf.1101, B.Inf.1841
Language: English	**Person responsible for module:** Prof. Dr. Jens Grabowski
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4

Georg-August-Universität Göttingen Module B.Inf.1351.A: Fundamentals of Biomedicine	6 C 4 WLH

Learning outcome, core skills:

Die Studierenden

- können grundlegende Themenfelder der Biomedizin beschreiben, voneinander abgrenzen und deren Bedeutung für die biomedizinische Forschung, Diagnostik und Therapie erläutern.
- können die für das jeweilige Themenfeld zentralen Begriffe nennen, definieren und anwenden.
- können die Bedeutung und Rolle der Medizininformatik für erfolgreiche biomedizinische Forschung beschreiben und anhand aktueller Forschungsprojekte und Publikationen exemplarisch erläutern.
- identifizieren interdisziplinäre Schnittstellen und können die Unterschiede und das Zusammenwirken von Biologie, Medizin und Informatik anhand von Anwendungsbeispielen beschreiben.

Workload:
Attendance time:
56 h
Self-study time:
124 h

Course: Grundlagen der Biomedizin I (Lecture)

Contents:

Biologie der Zelle, Bakterien, Viren, Genetik/Genomik, DNA/RNA/Phänotyp, Mutationen, Genexpressionsanalyse, genetisch bedingte Krankheiten, Gentherapie, Biobanken. Die Inhalte werden aktuellen Entwicklungen angepasst. Literaturempfehlungen werden zu Beginn des jeweiligen Semesters ausgegeben.

Course frequency: each winter semester

Examination: Klausur bzw. E-Prüfung (60 Min.) oder mündliche Prüfung (ca. 20 Min.)	3 C

Course: Grundlagen der Biomedizin II (Lecture)

Contents:

Gewebe, Organe, Organsysteme, Anatomie; Erkrankungen und Therapiemöglichkeiten, medizinische Disziplinen. Die Inhalte werden aktuellen Entwicklungen angepasst. Literaturempfehlungen werden zu Beginn des jeweiligen Semesters ausgegeben.

Course frequency: each summer semester

Examination: Klausur bzw. E-Prüfung (60 Min.) oder mündliche Prüfung (ca. 20 Min.)	3 C

Examination requirements:

In der Prüfung wird neben dem theoretischen Verständnis zentraler Begriffe und Methoden deren Auswahl, Einsatz und Überprüfung anhand von Fallbeispielen nachgewiesen. Lernziele werden zu jeder Lehreinheit ausgegeben. Prüfungsanforderungen werden in der Lehrveranstaltung durch geeignete Übungsaufgaben und/oder Repetitorien vermittelt. In Klausuren bzw. E-Prüfungen sind grundsätzlich offene Fragen in Textform zu bearbeiten, weitere Fragetypen (z. B. MC) sind in geringem Umfang möglich.

Admission requirements: keine	**Recommended previous knowledge:** Es wird empfohlen, die Lehrveranstaltungen in der durch die Nummerierung vorgegebenen Reihenfolge zu besuchen.
Language: German	**Person responsible for module:** Prof. Dr. rer. nat. Dagmar Krefting Prof. Dr. Ulrich Sax
Course frequency: each semester	**Duration:** 2 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 3 - 6; Master: 1 - 3
Maximum number of students: 50	

Georg-August-Universität Göttingen Module B.Inf.1709: Advanced Algorithms and Data Structures	5 C 4 WLH
Learning outcome, core skills: Die Studierenden haben vertiefte Kenntnisse und Kompetenzen auf einem Gebiet aus dem Bereich Algorithmen und Datenstrukturen erworben. Beispiele für solche Gebiete sind Algorithms on Sequences und Advanced Topics on Algorithms.	**Workload:** Attendance time: 56 h Self-study time: 94 h
Course: Algorithms on Sequences (Lecture, Exercise) *Contents*: This course is an introduction into the theory of stringology, or algorithms on sequences of symbols (also called words or strings). Our main intention is to present a series of basic algorithmic and combinatorial results, which can be used to develop efficient word-processing tools. While the emphasis of the course is on the theoretical side of stringology, we also present a series of applications of the presented concepts in areas like data-compression or computational biology. We expect that the participants to this course will gain an understanding of classical string-processing tools. They are supposed to understand and be able to use in various situations: classical text algorithms (e.g., pattern matching algorithms, edit distance), classical text indexing data structures (e.g., suffix arrays / trees), and classical combinatorial results that are useful in this context (e.g., periodicity lemmas). The main topics our course will cover are: basic combinatorics on words, pattern matching algorithms, data structures for text indexing (suffix arrays, suffix trees), text compression (Huffman encoding, Lempel-Ziv method), detection of regularities in words, algorithms for words with don't care symbols (partial words), word distance algorithms, longest common subsequence algorithms, approximate pattern matching. The presentation of each theoretical topic from the above will be accompanied by a brief discussion on its possible applications. Literature • T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein: Introduction to Algorithms (3rd Edition), MIT Press, 2009. • M. Crochemore, C. Hancart, T. Lecroq: Algorithms on Strings, Cambridge University Press, 2007. • M. Crochemore, W. Rytter: Jewels of Stringology, World Scientific, 2002. • D. Gusfield. Algorithms on strings, trees, and sequences: computer science and computational biology. Cambridge University Press, 1997. *Course frequency:* irregular	4 WLH
Course: Advanced Topics on Algorithms (Lecture, Exercise) *Contents*: In this course we present a series of selected results on data structures and efficient algorithms, and discuss a series of areas in which they can be applied successfully. The emphasis of the course is on the theory, we also approach the problem of a practical implementation of the presented algorithms.	4 WLH

We expect that the students that will participate in this lecture will become familiar with efficient sorting and searching methods, advanced data structures, dynamic data structures, as well as other efficient algorithmic methods, they will be able to estimate the complexity of those algorithms, and they will be able to apply those algorithms to particular programming problems (from practical or theoretical settings). The main topics our course will cover are: efficient sorting and searching (non-comparison based methods, van Emde Boas trees, Radix Sort), advanced tree-structures (Fibonacci heaps, B-Trees, structures for working with disjoint sets), dynamic data structures (range minimum queries, lowest common ancestor, applications to string algorithms: suffix arrays, suffix trees), Hashing and Dictionaries, Young tableaux, geometric algorithms (convex hull), number theoretic algorithms. The presentation of each theoretical topic from the above will be accompanied by a brief discussion on its possible applications. Literature • T.H. Cormen, C.E. Leiserson, R.L. Rivest, C. Stein: Introduction to Algorithms (3rd Edition), MIT Press, 2009. • E. Demaine: Advanced Data Structures, MIT Course nr. 6.851, 2012. • Pawel Gawrychowski and Mayank Goswami and Patrick Nicholson: Efficient Data Structures, MPI Course, Summer 2014. *Course frequency:* irregular	
Examination: Oral examination (approx. 20 minutes) **Examination requirements:** Algorithms on Sequences • basic combinatorics on words • pattern matching algorithms • data structures for text indexing (suffix arrays, suffix trees) • text compression (Huffman encoding, Lempel-Ziv method) • detection of regularities in words • algorithms for words with don't care symbols (partial words) • word distance algorithms • longest common subsequence algorithms • approximate pattern matching Advanced Topics on Algorithms • efficient sorting and searching (non-comparison based methods, van Emde Boas trees, Radix Sort) • advanced tree-structures (Fibonacci heaps, B-Trees, structures for working with disjoint sets) • dynamic data structures (range minimum queries, lowest common ancestor, applications to string algorithms: suffix arrays, suffix trees) • Hashing and Dictionaries • Young tableaux • geometric algorithms (convex hull) • number theoretic algorithms	5 C

Admission requirements: none	**Recommended previous knowledge:** B.Inf.1101, B.Inf.1103
Language: English	**Person responsible for module:** Prof. Dr. Florin Manea
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module B.Inf.1913: Advanced Topics in Natural Language Processing**	6 C 4 WLH
Learning outcome, core skills: Die Studierenden haben an einem konkreten Anwendungsfall (z.B. Sentimentanalyse, Semantic Role Labelling, Dialogsystem, Textgenerierung, Argumentationsanalyse, Informationsextraktion) vertiefende Kenntnisse über verschiedene Algorithmen und deren Vor- und Nachteile erworben. Im Rahmen von praktischen Übungen haben sie zudem Erfahrungen in der Erstellung, Pflege und Aufbereitung digitaler Textkorpora sowie in der Anwendung und Evaluation computerlinguistischer Software erlangt.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Vertiefung Computerlinguistik (Seminar)	2 WLH
Course: Vertiefung Computerlinguistik (Exercise)	2 WLH
Examination: Referat (ca. 30 Min.) und Hausarbeit (max. 15 Seiten) oder Projektbericht (max. 15 Seiten) **Examination prerequisites:** Regelmäßige und aktive Teilnahme an der Übung **Examination requirements:** Die Studierenden weisen vertiefte Kenntnisse einer spezifischen computerlinguistischen Fragestellung sowie deren algorithmischer Umsetzung nach und besitzen die Fähigkeit, computerlinguistische Algorithmen nachzuvollziehen und Forschungsergebnisse in Ansätzen zu reflektieren.	6 C

Admission requirements: none	**Recommended previous knowledge:** Kenntnisse der Linguistik und Computerlinguistik
Language: German, English	**Person responsible for module:** Prof. Dr. Caroline Sporleder
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module B.Mat.1300: Numerical linear algebra**	9 C 6 WLH

Learning outcome, core skills: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden im Schwerpunkt "Numerische und Angewandte Mathematik" vertraut. Sie • gehen sicher mit Matrix- und Vektornormen um; • formulieren für verschiedenartige Fixpunktgleichungen einen geeigneten Rahmen, der die Anwendung des Banachschen Fixpunktsatzes erlaubt; • beurteilen Vor- und Nachteile von direkten und iterativen Lösungsverfahren für lineare Gleichungssysteme, insbesondere von Krylovraumverfahren, und analysieren die Konvergenz iterativer Verfahren; • lösen nichtlineare Gleichungssysteme mit dem Newtonverfahren und analysieren dessen Konvergenz; • formulieren quadratische Ausgleichsprobleme zur Schätzung von Parametern aus Daten und lösen sie numerisch; • berechnen numerisch Eigenwerte und -vektoren von Matrizen. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Kompetenzen im Schwerpunkt "Numerische und Angewandte Mathematik" erworben. Sie sind in der Lage, • grundlegende Verfahren zur numerischen Lösung von mathematischen Problemen anzuwenden; • numerische Algorithmen in einer Programmiersprache oder einem Anwendersystem zu implementieren; • Grundprinzipien der Konvergenzanalysis numerischer Algorithmen zu nutzen.	**Workload:** Attendance time: 84 h Self-study time: 186 h

Course: Numerische Mathematik I (Lecture)	4 WLH
Examination: Written examination (120 minutes) **Examination prerequisites:** B.Mat.1300.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Course: Numerische Mathematik I - Übung (Exercise)	2 WLH

Examination requirements: Nachweis der Grundkenntnisse der numerischen und angewandten Mathematik	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.0021, B.Mat.0022
Language: German	**Person responsible for module:** Studiengangsbeauftragte/r

Course frequency: each winter semester	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 5
Maximum number of students: not limited	

Additional notes and regulations:

- Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik
- Universitätsweites Schlüsselkompetenzangebot; als solches nicht verwendbar für Studierende im Zwei-Fächer-Bachelor Studiengang mit Fach Mathematik, Studiengang Master of Education mit Fach Mathematik, Bachelor/Master-Studiengang Mathematik und Promotionsstudiengang Mathematical Sciences.

Georg-August-Universität Göttingen Module B.Mat.1400: Measure and probability theory	9 C 6 WLH

Learning outcome, core skills: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit den Grundbegriffen und Methoden der Maßtheorie sowie auch der Wahrscheinlichkeitstheorie vertraut, die die Grundlage des Schwerpunkts "Mathematische Stochastik" bilden. Sie • modellieren diskrete Wahrscheinlichkeitsräume, beherrschen die damit verbundene Kombinatorik sowie den Einsatz von Unabhängigkeit und bedingten Wahrscheinlichkeiten; • kennen die wichtigsten Verteilungen von Zufallsvariablen; • verstehen grundlegende Eigenschaften sowie Existenz und Eindeutigkeitsaussagen von Maßen; • gehen sicher mit allgemeinen Maß-Integralen um, insbesondere mit dem Lebesgue-Integral; • kennen sich mit Lp-Räumen und Produkträumen aus; • formulieren wahrscheinlichkeitstheoretische Aussagen mit Wahrscheinlichkeitsräumen, Wahrscheinlichkeitsmaßen und Zufallsvariablen; • rechnen und modellieren mit stetigen und mehrdimensionalen Verteilungen; • beschreiben Wahrscheinlichkeitsmaße mit Hilfe von Verteilungsfunktionen bzw. Dichten; • verstehen und nutzen das Konzept der Unabhängigkeit; • berechenen Erwartungswerte von Funktionen von Zufallsvariablen; • verstehen die verschiedenen stochastischen Konvergenzbegriffe und ihre Beziehungen; • kennen charakteristische Funktionen und deren Anwendungen; • besitzen Grundkenntnisse über bedingte Wahrscheinlichkeiten und bedingte Erwartungswerte; • verwenden das schwache Gesetz der großen Zahlen und den zentralen Grenzwertsatz; • kennen einfache stochastische Prozesse wie z.B. Markov-Ketten. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Kompetenzen im Schwerpunkt "Mathematische Stochastik" erworben. Sie sind in der Lage, • Maßräume und Maß-Integrale anzuwenden; • stochastische Denkweisen einzusetzen und einfache stochastische Modelle zu formulieren; • stochastische Modelle mathematisch zu analysieren; • die wichtigsten Verteilungen zu verstehen und anzuwenden; • stochastische Abschätzungen mit Hilfe von Wahrscheinlichkeitsgesetzen durchzuführen;	**Workload:** Attendance time: 84 h Self-study time: 186 h

• grundlegende Grenzwertsätze der Wahrscheinlichkeitstheorie zu verwenden.	

Course: Maß- und Wahrscheinlichkeitstheorie (Lecture)	4 WLH
Examination: Written examination (120 minutes) **Examination prerequisites:** B.Mat.1400.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Course: Maß- und Wahrscheinlichkeitstheorie - Übung (Exercise)	2 WLH

Examination requirements: Nachweis von Grundkenntnissen in diskreter Stochastik sowie Maß- und Wahrscheinlichkeitstheorie	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.0021, B.Mat.0022
Language: German	**Person responsible for module:** Studiengangsbeauftragte/r
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 5
Maximum number of students: not limited	

Additional notes and regulations: Dozent/in: Lehrpersonen des Instituts für Mathematische Stochastik

Georg-August-Universität Göttingen Module B.Mat.2300: Numerical analysis	9 C 6 WLH

Learning outcome, core skills: Lernziele: Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit weiterführenden Begriffen und Methoden im Schwerpunkt "Numerische und angewandte Mathematik" vertraut. Sie • interpolieren vorgegebene Stützpunkte mit Hilfe von Polynomen, trigonometrischen Polynomen und Splines; • integrieren Funktionen numerisch mit Hilfe von Newton-Cotes Formeln, Gauß-Quadratur und Romberg-Quadratur; • modellieren Evolutionsprobleme mit Anfangswertaufgaben für Systeme von gewöhnlichen Differenzialgleichungen, lösen diese numerisch mit Runge-Kutta-Verfahren und analysieren deren Konvergenz; • erkennen die Steifheit von gewöhnlichen Differenzialgleichungen und lösen entsprechende Anfangswertprobleme mit impliziten Runge-Kutta-Verfahren; • lösen je nach Ausrichtung der Veranstaltung Randwertprobleme oder sind mit Computer Aided Graphic Design (CAGD), Grundlagen der Approximationstheorie oder anderen Gebieten der Numerischen Mathematik vertraut. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage • Algorithmen zur Lösung mathematischer Probleme zu entwickeln und • deren Stabilität, Fehlerverhalten und Komplexität abzuschätzen.	**Workload:** Attendance time: 84 h Self-study time: 186 h

Course: Numerische Mathematik II - Übung	2 WLH

Course: Numerische Mathematik II	4 WLH
Examination: Written examination (120 minutes) **Examination prerequisites:** B.Mat.2300.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Examination requirements: Nachweis weiterführender Kenntnisse in numerischer Mathematik	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1300
Language: German	**Person responsible for module:** Studiengangsbeauftragte/r
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**

twice	4 - 6
Maximum number of students: not limited	

Additional notes and regulations: Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen Module B.Mat.2310: Optimisation	9 C 6 WLH
Learning outcome, core skills: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der Optimierung vertraut. Sie • lösen lineare Optimierungsprobleme mit dem Simplex-Verfahren und sind mit der Dualitätstheorie der linearen Optimierung vertraut; • beurteilen Konvergenzeigenschaften und Rechenaufwand von grundlegenden Verfahren für unrestringierte Optimierungsprobleme wie Gradienten- und (Quasi-)Newton-Verfahren; • kennen Lösungsverfahren für nichtlineare, restringierte Optimierungsprobleme und gehen sicher mit den KKT-Bedingungen um; • modellieren Netzwerkflussprobleme und andere Aufgaben als ganzzahlige Optimierungsprobleme und erkennen totale Unimodularität. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, • Optimierungsaufgaben in der Praxis zu erkennen und als mathematische Programme zu modellieren sowie • geeignete Lösungsverfahren zu erkennen und zu entwickeln.	**Workload:** Attendance time: 84 h Self-study time: 186 h
Course: Übungen *Course frequency:* each winter semester	2 WLH
Course: Vorlesung (Lecture)	4 WLH
Examination: Written examination (120 minutes) **Examination prerequisites:** B.Mat.2310.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C
Examination requirements: Nachweis der Grundkenntnisse der Optimierung	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.0021, B.Mat.0022
Language: German	**Person responsible for module:** Studiengangsbeauftragte/r
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4 - 6
Maximum number of students:	

not limited	

Additional notes and regulations:

- Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik
- Universitätsweites Schlüsselkompetenzangebot; als solches nicht verwendbar für Studierende im Zwei-Fächer-Bachelor Studiengang mit Fach Mathematik, Studiengang Master of Education mit Fach Mathematik, Bachelor/Master-Studiengang Mathematik und Promotionsstudiengang Mathematical Sciences.

Georg-August-Universität Göttingen Module B.Mat.2420: Statistical Data Science	9 C 6 WLH

Learning outcome, core skills: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit den Methoden und Denkweisen der Statistical Data Science vertraut. Sie • gehen sicher mit den Grundbegriffen der deskriptiven Methoden der Statistical Data Science um wie etwa Histogrammen, Quantilen und anderen Kenngrößen von Verteilungen; • kennen für die Statistical Data Science relevante Verteilungen von diskreten und stetigen Zufallsvariablen; • erlernen grundlegende Algorithmen zur Erzeugung von Zufallszahlen und Computersimulationen; • verstehen grundlegende stochastische Konvergenzbegriffe und Konvergenzsätze, elementare Beweistechniken und ihre Verwendung in der Statistical Data Science; • konstruieren Schätzer wie etwa Maximum Likelihood-Schätzer, Momentenschätzer, Bayes-Schätzer und Kerndichteschätzer und kennen ihre elementaren Eigenschaften wie mittlerer quadratischer Fehler und Konsistenz; • sind mit den zentralen Begrifflichkeiten zur Bewertung des Risikos dieser Schätzer vertraut; • erlernen algorithmische Verfahren der Statistical Data Science zur Berechnung dieser Schätzer; • entwickeln Konfidenzbereiche zur Parameterschätzung; • formulieren Hypothesentests und kennen ihre Grundlagen und Eigenschaften; • sind mit Methoden von besonderer Wichtigkeit in verschiedenen Gebieten der Statistical Data Science vertraut wie etwa Varianz-, Cluster-, Diskriminanz-, Hauptkomponenten- und Regressionsanalyse. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Kompetenzen im Bereich Statistical Data Science erworben. Sie sind in der Lage, • statistische Denkweisen und deskriptive Methoden der Statistical Data Science anzuwenden; • elementare Modelle der Statistical Data Science zu formulieren; • grundlegende Schätzmethoden zu verwenden sowie Hypothesentests und einfache cluster- und diskriminanzanalytische Verfahren durchzuführen; • konkrete Datensätze zu analysieren und entsprechende Verfahren der Statistical Data Science einzusetzen.	**Workload:** Attendance time: 84 h Self-study time: 186 h

Course: Statistical Data Science (Lecture)	4 WLH
Examination: Written examination (120 minutes) **Examination prerequisites:** B.Mat.2420.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Course: Statistical Data Science - Übung (Exercise)	2 WLH

Examination requirements: Nachweis weiterführender Kenntnisse in Statistical Data Science	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.0034, B.Mat.1400
Language: German	**Person responsible for module:** Studiengangsbeauftragte/r
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4 - 6
Maximum number of students: not limited	

Additional notes and regulations:

- Dozent/in: Lehrpersonen des Instituts für Mathematische Stochastik
- Universitätsweites Schlüsselkompetenzangebot

<table>
<tr><td>Georg-August-Universität Göttingen
Module B.Phy.5601: Theoretical and Computational Neuroscience I</td><td>3 C
2 WLH</td></tr>
<tr><td>Learning outcome, core skills:
Nach erfolgreichem Absolvieren des Moduls sollten die Studierenden...
ein vertieftes Verständnis folgender Themen entwickelt haben: TCN I: biophysikalische Grundlagen neuronaler Anregbarkeit, mathematische Grundlagen neuronaler Anregbarkeit, Input-Output Beziehungen und Bifurkationen, Klassifizierung, Existenz, Stabilitaet und Koexistenz sychroner und asynchroner Zustaende in spikenden neuronalen Netzwerken;
Methoden und Methodenentwicklung für die Analyse hochdimensionaler Modelle ratenkodierter Einheiten in Feldmodellen verstehen;
die Handhabung von Bifurkationsszenarien und zugehörigen Instabilitäten verstanden haben.</td><td>Workload:
Attendance time:
28 h
Self-study time:
62 h</td></tr>
<tr><td>Course: Collective Dynamics Biological Neural Networks I (Lecture)</td><td></td></tr>
<tr><td colspan="2">Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:</td></tr>
<tr><td>Examination: Written examination (120 minutes)</td><td>3 C</td></tr>
<tr><td>Examination: Oral examinationMündliche Prüfung (approx. 30 minutes)</td><td>3 C</td></tr>
<tr><td>Examination: Vortrag (2 Wochen Vorbereitungszeit) (30 minutes)</td><td>3 C</td></tr>
<tr><td>Examination requirements:
Grundlagen der Membranbiophysi;, Bifurkationen anregbarer Systeme; Verständnis der Grundlagen der Modellierungsansätze der Neurophysik; kollektive Zustände spikender neuronaler Netzwerke; insbesondere Synchonizität; Balanced State; Phase-Locking und diesen Zuständen unterliegenden lokalen und Netzwerkeigenschaften: Netzwerktopologie; Delays; inhibitorische und exzitatorische Kopplung; sparse random networks</td><td></td></tr>
</table>

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Fred Wolf
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 4 - 6; Master: 1
Maximum number of students: 90	

Georg-August-Universität Göttingen Module B.Phy.5602: Theoretical and Computational Neuroscience II	3 C 2 WLH

Learning outcome, core skills: Nach erfolgreichem Absolvieren des Moduls sollten Studierende... • das vertiefte Verständnis folgender Themen entwickelt haben: TCN II: Grundlagen neuronaler Anregbarkeit, Input-Output Beziehungen bei Einzelneuronen, eindimensionale Feldmodelle (Feature Selectivity, Contrastinvariance), zweidimensionale Feldmodell (Zusammenwirken von kurz- und langreichweitigen Verbindungen sowie lokaler Nichtlinearitaeten), Amplitudengleichungen und ihre Loesungen; • Methoden und Methodenentwicklung für die Analyse spikender neuronaler Netzwerke mit und ohne Delays, Handhabung von Bifurkationsszenarien und zugehörigen Instabilitäten verstehen.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Collective Dynamics Biological Neural Networks II (Lecture)	

Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:	
Examination: Written examination (120 minutes)	3 C
Examination: Oral examination (approx. 30 minutes)	3 C
Examination: Seminarvortrag (2 Wochen Vorbereitungszeit) (30 minutes)	3 C

Examination requirements: Ratenmodelle von Einzelneuronen; Feldansatz in der theoretischen Neurophysik; Grundlagen der Bifurkationen anregbarer System; Verständnis der Grundlagen der Modellierungsansätze der Neurophysik; Zusammenhang diskrete/kontinuierliche Modelle; kollektive Zustände ein- und zweidimensionaler Feldmodelle, insbesondere ring model of feature selectivity; orientation preference maps.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Fred Wolf
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 4 - 6; Master: 1
Maximum number of students: 90	

Georg-August-Universität Göttingen Module B.Phy.5605: Computational Neuroscience: Basics	3 C 2 WLH

Learning outcome, core skills: **Goals:** Introduction to the different fields of Computational Neuroscience: • Models of single neurons, • Small networks, • Implementation of all simple as well as more complex numerical computations with few neurons. • Aspects of sensory signal processing (neurons as ‚filters'), • Development of topographic maps of sensory modalities (e.g. visual, auditory) in the brain, • First models of brain development, • Basics of adaptivity and learning, • Basic models of cognitive processing. **Kompetenzen/Competences:** On completion the students will have gained… • … overview over the different sub-fields of Computational Neuroscience; • … first insights and comprehension of the complexity of brain function ranging across all sub-fields; • … knowledge of the interrelations between mathematical/modelling methods and the to-be-modelled substrate (synapse, neuron, network, etc.); • … access to the different possible model level in Computational Neuroscience.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Computational Neuroscience: Basics (Lecture)	
Examination: Written examination (45 minutes) **Examination requirements:** Actual examination requirements: Having gained overview across the different sub-fields of Computational Neuroscience; Having acquired first insights into the complexity of across the whole bandwidth of brain function; Having learned the interrelations between mathematical/modelling methods and the to-be-modelled substrate (synapse, neuron, network, etc.) Being able to realize different level of modelling in Computational Neuroscience.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Florentin Andreas Wörgötter
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 2 - 6; Master: 1 - 4

Georg-August-Universität Göttingen Module B.Phy.5651: Advanced Computational Neuroscience	3 C 2 WLH
Learning outcome, core skills: Participants in the course can explain and relate biological foundations and mathematical modelling of selected (neuronal) algorithms for learning and pattern formation. Based on the the algorithms' properties, they can discuss and derive possible technical applications (robots).	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Advanced Computational Neuroscience I (Lecture)	
Examination: Written examination (90 Min.) or oral examination (approx. 20 Min.) **Examination requirements:** Algorithms for learning: • Unsupervised Learning (Hebb, Differential Hebb), • Reinforcement Learning, • Supervised Learning Algorithms for pattern formation. Biological motivation and technical Application (robots).	3 C

Admission requirements: none	**Recommended previous knowledge:** Basics Computational Neuroscience
Language: English	**Person responsible for module:** Prof. Dr. Florentin Andreas Wörgötter
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 50	

Additional notes and regulations:
Hinweis: Die B.Phy.5652 kann als vorlesungsbegleitendes Praktikum besucht werden.

Georg-August-Universität Göttingen Module B.Phy.5652: Advanced Computational Neuroscience II	3 C 2 WLH
Learning outcome, core skills: Participants in the course can implement, test, and evaluate the properties of selected (neuronal) algorithms for learning and pattern formation.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Advanced Computational Neuroscience II	
Examination: 4 Protocols (max. 3 Pages) and Presentations (ca. 10 Min.), not graded **Examination requirements:** Algorithms for learning: • Unsupervised Learning (Hebb, Differential Hebb), • Reinforcement Learning, • Supervised Learning Algorithms for pattern formation. Biological motivation and technical Application (robots). *For each of the 4 programming assignments 1 protocol (ca. 3 pages) and 1 oral presentations (demonstration and discussion of the program, ca. 10 min).*	3 C

Admission requirements: B.Phy.5651 (can be taken in parallel to B.Phy.5652)	**Recommended previous knowledge:** Programming in C++, basic numerical algorithms, Grundlagen Computational Neuroscience B.Phy.5504: Computational Physics (Scientific Computing)
Language: English	**Person responsible for module:** Prof. Dr. Florentin Andreas Wörgötter
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 24	

Georg-August-Universität Göttingen **Module B.Psy.902: Biological Psychology: Neurosciences**	8 C 4 WLH
Learning outcome, core skills: Students acquire extended basic knowledge and concepts of neuroscientific biopsychology in the fields of neuroscience methods, evolution of the nervous system, individual development, somatosensation, neuroplasticity, pain, multisensory integration, sensorimotor neuroscience, decision making, executive functions, attention, psychopathology, and psychopharmacology. Students acquire in-depth knowledge in a selected subject area. Academic achievements: Students deepen their knowledge through documented individual or group work (seminar hour) with their own oral presentation and active participation in discussions on other presentations.	**Workload:** Attendance time: 56 h Self-study time: 184 h
Course: Biological Psychology: Neurosciences 1 (Lecture)	2 WLH
Course: Biological Psychology: Neurosciences 2 (Seminar)	2 WLH
Examination: Written examination (60 minutes)	8 C
Examination requirements: Students provide proof of knowledge about the foundations and concepts in neuroscientific biopsychology in the fields of neuroscience methods, evolution of the nervous system, individual development, somatosensation, neuroplasticity, pain, multisensory integration, sensorimotor neuroscience, decision making, executive functions, attention, psychopathology, and psychopharmacology.	

Admission requirements: B.Psy.101, B.Psy.102	**Recommended previous knowledge:** B.Psy.204, B.Psy.901
Language: German	**Person responsible for module:** Prof. Dr. Alexander Gail
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** from 5
Maximum number of students: not limited	

Additional notes and regulations:
Max. number of participants:
Lecture: not limited
Seminar: 30 participants

Georg-August-Universität Göttingen **Module M.Bio.141: General and applied microbiology**	3 C 3 WLH

Learning outcome, core skills: **Learning outcome:** Evolution and phylogenetic system; morphology and cell biology; communities and biocoenosis of bacteria and archaea; gene expression and molecular control (transcription, translation); posttranslational control, protein stability and proteomics; genetic networks; molecular switches and signal transduction; microbial developmental biology; mechanisms of pathogenicity of important pathogens; development of new antimicrobial agents; diversity of the metabolism in bacteria and archaea as basis for biotechnological applications; industrial microbiology. **Core skills:** Knowledge of microorganisms relevant for biotechnology and medicine, ability to identify these organisms and to analyse them with molecular methods.	**Workload:** Attendance time: 42 h Self-study time: 48 h

Course: lecture: General and applied microbiology (Lecture)	3 WLH
Examination: Written examination (90 minutes)	3 C

Examination requirements: detailed knowledge in cell biology, biochemistry and genetics of procaryotic microorgansims	

Admission requirements: can't be combined with core module M.Bio.101	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Jörg Stülke
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Bio.142: Molecular genetics and microbial cell biology**	3 C 3 WLH

Learning outcome, core skills: Advanced knowledge of Molecular Genetics and microbial cell biology through case studies of model systems of molecular mycology (yeasts and filamentous fungi). Acquisation of knowledge up to the "Review" level in one topic.	**Workload:** Attendance time: 42 h Self-study time: 48 h

Course: Molecular genetics and microbial cell biology (Lecture)	3 WLH
Examination: Written examination (90 minutes)	3 C

Examination requirements: detailed knowledge in cell biology, biochemistry and genetics of eucaryotic microorgansims	

Admission requirements: Can´t be combined with Core Module M.Bio.102	**Recommended previous knowledge:** • Watson, Molecular Biology of the Gene, Pearson, 6th Edition • Alberts, Molecular Biology of the Cell, Garland, 5th Edition
Language: English	**Person responsible for module:** Prof. Dr. Gerhard Braus
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Bio.144: Cellular and molecular biology of plant-microbe interactions**	3 C 3 WLH
Learning outcome, core skills: Introduction into theory and methods for the analysis of plant-microbe interactions on the cell biological and molecular level.	**Workload:** Attendance time: 42 h Self-study time: 48 h
Course: lecture: Plant-microbe-interactions (Lecture)	3 WLH
Examination: Written examination (54 minutes)	3 C
Examination requirements: knowledge of basic concepts in plant-microbe-interactions	

Admission requirements: Can´t be combined with core module M.Bio.104	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Christiane Gatz Prof. Dr. Volker Lipka
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Bio.157: Biochemistry and biophysics**	3 C 3 WLH

Learning outcome, core skills: Molecular biochemistry and biophysics of different classes of biomolecules, plant primary and secondary metabolism, lipid metabolism, lipids as signal molecules and secondary metabolites, biotechnological utilization and modification of storage substances, enzymes of lipid metabolism, modern biophysical methods for analysis of biomolecules Handling of state of the art equipment, critical dealing with current biochemical topics, detailed analysis of experiments and their presentation. Independent acquisition of professional knowledge from publications by active participation in the seminar.	**Workload:** Attendance time: 42 h Self-study time: 48 h

Course: lecture: Biochemistry and Biophysics (Lecture)	3 WLH
Examination: Written examination (90 minutes)	3 C

Examination requirements: • basic knowledge of different classes of biomolecules and their metabolism • knowledge about spectroscopy of molecules • biotechnologic techniques using plants	

Admission requirements: can't be combined with M.Bio.106	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Ivo Feußner
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Bio.310: Systems biology**	12 C 14 WLH

Learning outcome, core skills: Subject of this module are the formal description, modeling, analysis and simulation of complex interactions between the components (molecules, cells, organs) of living systems on different levels of abstraction. Biomolecular networks, like networks of metabolic signaling and transduction will be introduced and various graph based abstractions of interaction networks will be demonstrated (entity interaction graph, boolean networks, Petri networks). The students will get to know basics of the graph theory (analysis of paths, cluster coefficients, centrality, etc.) and they will learn how to apply the respective theory to biomolecular networks. The students will be introduced to different high-throughput techniques and their application to biomolecular networks. The simulation of molecular networks will be presented by selected examples.	**Workload:** Attendance time: 147 h Self-study time: 213 h

Course: Bioinformatics of systems biology (Lecture)	2 WLH
Examination: Oral examination (approx. 30 minutes)	6 C

Course: Bioinformatics of systems biology (Exercise)	2 WLH
Course: Bioinformatics of systems biology (Seminar)	1 WLH

Course: Methods course 'Modelling and analysis of biological systems' 3 weeks full time	9 WLH
Examination: Minutes / Lab report (max. 10 pages) **Examination prerequisites:** oral presentation (ca. 30 min), regular attendance	6 C

Examination requirements: Ability to model, analyze and simulate biomolecular networks	

Admission requirements: can't be combined with M.Bio.340	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Tim Beißbarth
Course frequency: each summer semester; verschieden; siehe Lehrveranstaltungen	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Bio.323: Introduction to Bayesian Statsistics and Information Theory**	12 C 12 WLH

Learning outcome, core skills: *The students learn the basic concepts and main applications of Bayesian Statistics, in particular Bayesian probabilities, parameter estimation and Bayesian credible intervals, importance and choice of prior distributions based on prior knowledge, Bayesian hypothesis testing, model tests and MCMC methods. All concepts will be presented in lectures and worked with in hands-on computer assignments. The module closes with a foray into information theory.*	**Workload:** Attendance time: 195 h Self-study time: 165 h

Course: Introduction to Bayesian Inference and Information Theory (Lecture)	3 WLH
Course: Classical problems in Bayesian Interference (Seminar)	1 WLH

Course: Programmierkurs	8 WLH
Examination: Written examination, not graded	

Examination: Written examination (90 minutes) **Examination prerequisites:** regular attendance, oral presentation in seminar	12 C

Examination requirements: Knowledge of the foundations of Bayesian probabilities and statistics and the ability to solve simple classic problems in Bayesian Inference.	

Admission requirements: none	**Recommended previous knowledge:** basics in probability calculation
Language: English	**Person responsible for module:** Prof. Dr. Michael Wibral
Course frequency: each winter semester	**Duration:**
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Bio.344: Neurobiology 1 (key competence module)**	3 C 2 WLH

Learning outcome, core skills: Profound knowledge of essential techniques in molecular, cellular and systemic neuroscience and their application.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: From gene to behavior (Lecture)	2 WLH
Examination: Written examination (60 minutes)	3 C

Examination requirements: Theoretical knowledge of the basic methods in neuroscience based on the contents of the lecture.	

Admission requirements: can't be combined with module M.Bio.304	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Göpfert
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 27	

Georg-August-Universität Göttingen **Module M.Bio.373: Visual psychophysics - from theory to experiment**	3 C 2 WLH

Learning outcome, core skills: This introductory course is a mixture of lecture, seminar and practical exercises and emphasizes the importance of psychophysics as a central method in human perceptual and sensorimotor research. As well as gaining an understanding of the underlying theoretical principles, by the end of the course students should be able to critically assess published studies and to design and conduct their own simple psychophysical experiments.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Psychophysics advanced (computer-pool-practical)	1 WLH
Course: Psychophysics basics (Lecture)	1 WLH
Examination: Written examination (60 minutes) **Examination prerequisites:** regular attendance **Examination requirements:** Die Studierenden erbringen den Nachweis, dass sie die grundlegenden Methoden der Psychophysik kennen. Sie besitzen das theoretische Fachwissen um kleinere psychophysische Studien durchzuführen.	3 C

Examination requirements: Ability to demonstrate knowledge of the fundamental methods of psychophysics. Capability of conducting simple psychophysical studies.	

Admission requirements: attendance in the lecture: Biologische Psychologie II/ Kognitive Neurowissenschaften orequivalent course. The participation in the course M.Bio.373 "MATLAB in Biospychology and Neuroscience" during the first half of the term is strongly advised.	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Stefan Treue
Course frequency: each summer semester; second half	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Additional notes and regulations: Die Veranstaltung ist geeignet für hoch motivierte Bachelor- und Master-Studierende der Psychologie, Biologie und Physik, die überdurchschnittliches Forschungsinteresse haben.

Georg-August-Universität Göttingen **Module M.Bio.375: Neurorehabilitation Technologies: Introduction and Applications**	2 C 2 WLH

Learning outcome, core skills: Students are able to describe the state of the art in Neurorehabilitation technologies and understand the basics of the related physiological processes. They are in a position to discuss and evaluate current trends as well as to recognize limitations of available assistive and (neuro)rehabilitation technology. The programming and lab exercises will allow students to address variety of practical Neurorehabilitation challenges.	**Workload:** Attendance time: 28 h Self-study time: 32 h

Course: Introduction to Neurorehabilitation Technologies (Seminar) *Contents*: • Basic motor physiology • Biophysiological signal acquisition and processing • Invasive and non-invasive man-machine interfaces • Upper limb related technologies • Lower limb related technologies • Feedback for sensory-motor integration and rehabilitation • Selected topics on advanced technologies and their applications	1 WLH
Examination: Presentation (approx. 20 min.) and written elaboration (max. 5 pages), not graded **Examination prerequisites:** Participation and successful completion of all laboratory exercises.	3 C

Course: Neurorehabilitation Technologies (Exercise) *Contents*: • Biophysiological signal acquisition and processing • Prosthesis control • Motion analysis	1 WLH

Examination requirements: Students show that they are able to present and critically reflect scientific publications. They are familiar with the basic principles of neurorehabilitation technologies.	

Admission requirements: none	**Recommended previous knowledge:** basic programming skills (B.Inf.1801/1802) basic knowledge in neurophysiology (B.Bio.123; M.Bio.304)
Language: English	**Person responsible for module:** Prof. Dr. Arndt Schilling; Dr. Marko Markovic
Course frequency: each winter semester1	**Duration:**

Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 16	

Additional notes and regulations: Literature suggestions will be handed out at the beginning of each term. However, the students are expected to independently perform literature research on the selected topic.

Georg-August-Universität Göttingen **Module M.DH.01: Advanced Topics in Digital Humanities**	6 C 4 WLH
Learning outcome, core skills: The students • have an overview of central methods and theories from one or more subject areas of the Digital Humanities; • are able to comprehend and discuss the scientific discussions about it; • are familiar with the complexity, heterogeneity or fuzziness of data in the humanities and the specific characteristics of the Digital Humanities; • know typical examples for the scientific categorisation of texts, persons, images and objects, ideas and processes and can relate them to each other; • can discuss, test and, if necessary, modify these approaches with regard to their applicability.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Lecture	2 WLH
Course: Seminar	2 WLH
Examination: Presentation (approx. 20 min.) with written elaboration (max. 10 pages) **Examination prerequisites:** Regular participation in the seminar **Examination requirements:** The students discuss research results of the Digital Humanities and have the ability to evaluate methods and theories and to modify them in approaches.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Langner
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.DH.10: Theories and Research Questions in Digital Language Analysis**	9 C 4 WLH
Learning outcome, core skills: The students • know the possibilities of comprehensive digital language development and analysis; • can analyse grammatical structures of a lexical, morphological, phonetic-phonological, syntactic, semantic and discursive nature of written or spoken language using digital means and are familiar with their use in linguistic and extralinguistic contexts (pragmatics and discourse); • possess the ability to answer humanities questions from the core areas of linguistics using computer-assisted methods; • are able to digitally model the specific characteristics of language and relate these to each other as well as to the extralinguistic context.	**Workload:** Attendance time: 56 h Self-study time: 214 h
Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** Regular participation in the seminar and digital implementation of the exercises. **Examination requirements:** Students reflect on the results of specific linguistic research and have the ability to evaluate methods and theories and to modify them in approaches. The examination is to be taken in the seminar.	9 C
Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Caroline Sporleder
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen Module M.DH.11: Theories and Research Questions in Digital Text Analysis	9 C 4 WLH
Learning outcome, core skills: The students • know the possibilities of comprehensive digital text indexing, analysis and presentation; • have an overview of computer-assisted research questions from the whole spectrum of philological and cultural-historical disciplines, starting with the digitisation of data and the construction of suitable corpora for specific questions, through their manual and automatic preparation, to the selecting and applying appropriate methods of text analysis and the textminings as well as for the evaluation and presentation of the results; • are able to digitally acquire, analyse and model the specific characteristics of texts and text collections; • are able to evaluate the approaches used and to reflexively apply the analytical knowledge to themselves and their actions.	**Workload:** Attendance time: 56 h Self-study time: 214 h
Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** Regular participation in the seminar as well as successful digital implementation of the given exercises. **Examination requirements:** Students reflect on the results of specific research in textual studies and have the ability to evaluate and modify methods and theories. The examination is to be taken in the seminar.	9 C
Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Caroline Sporleder
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.DH.12: Theories and Research Questions in Digital Literature Analysis**	9 C 4 WLH

Learning outcome, core skills: The students • have an overview of methods and research questions in digital literary studies; • know computer-assisted procedures for indexing, processing, analysing and presenting literary works; • are also familiar with different forms of digital literature (such as fan fiction, collaborative fiction, computer-generated literary works or lay and expert reviews); • know possibilities of digital mediation between the texts and the historical or contemporary circumstances as well as the analysis of their meanings and have the ability to discuss these in a fundamental reflection on methods; • are able to evaluate the approaches used and to reflexively apply the analytical knowledge to themselves and their actions; • are able to digitally model the scientific categorisations of persons, texts, spaces, ideas or processes and relate them visually to each other.	**Workload:** Attendance time: 56 h Self-study time: 214 h

Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** Regular participation in the seminar as well as successful digital implementation of the given exercises. **Examination requirements:** Students reflect on the results of specific research in literary studies and have the ability to evaluate and modify methods and theories. The examination is to be taken in the seminar.	9 C

Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Caroline Sporleder
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.DH.13: Theories and Research Questions in Digital Image Analysis**	9 C 4 WLH
Learning outcome, core skills: The students • know the possibilities of a comprehensive digital image indexing and analysis, which includes not only colour, contrast and form but also the content and compositional structures contained in the images; • possess the ability to analyse humanities questions from the core areas of image and information science using computer-assisted methods; • are able to digitally model the specific characteristics of images and relate them to each other; • are able to evaluate the solution approaches used and to apply the analytical knowledge reflexively to themselves and their actions.	**Workload:** Attendance time: 56 h Self-study time: 214 h
Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** Regular participation in the seminar as well as successful digital implementation of the given exercises. **Examination requirements:** The students reflect on the results of specific research in the field of image science and have the ability to evaluate methods and theories and to modify them in approaches.	9 C
Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Langner
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.DH.14: Theories and Research Questions in Digital Object Analysis / Materiality**	9 C 4 WLH
Learning outcome, core skills: The students • know the possibilities of comprehensive digital material indexing and analysis, which, in addition to the form, also includes the properties with regard to their materiality and formal variability of an object and its inherent possibilities of use; • possess the ability to analyse research topics from the humanities from the core areas of object and information science with computer-assisted methods; • are able to digitally model the specific characteristics of objects and their shape and relate them to each other; • are able to evaluate the approaches used and to reflexively apply the analytical knowledge to themselves and their actions.	**Workload:** Attendance time: 56 h Self-study time: 214 h
Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** regRegular participation in the seminar as well as successful digital implementation of the given exercises. **Examination requirements:** The students reflect on the results of specific object science research and have the ability to evaluate methods and theories and to modify them in approaches.	9 C
Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Langner
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.DH.15: Theories and Research Questions in Digital Spatial Analysis**	9 C 4 WLH

Learning outcome, core skills: The students • have in-depth knowledge of the theory and application of geoinformation systems (GIS) and digital building surveys; • possess the ability to analyse research topics from the humanities from the core areas of geosciences and information science using computer-based methods; • are able to digitally model the specific characteristics of buildings and topographical features and their form and relate them to each other; • are able to evaluate the approaches used and to reflexively apply the analytical knowledge to themselves and their actions.	**Workload:** Attendance time: 56 h Self-study time: 214 h

Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** Regular participation in the seminar as well as successful digital implementation of the given exercises. **Examination requirements:** The students reflect on the results of specific research in image and object science on the contextuality of things and have the ability to evaluate methods and theories and to modify them in approaches. The examination is to be taken in the seminar.	9 C

Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Langner
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen Module M.DH.16: Digital Analysis of Historical Contexts	9 C 4 WLH
Learning outcome, core skills: The students • can integrate pictorial works and objects into their contexts of use, the historical discourse or the modern research situation; • know possibilities of digital mediation between the "silent" artefacts and the historical or contemporary circumstances; • possess the ability to analyse the significance of historical contexts with digital methods and to discuss them in a fundamental reflection on methods; • are able to digitally model the scientific categorisations of people, images and objects, spaces, ideas or processes and relate them visually to each other; • are able to evaluate the approaches used and to reflexively apply the analytical knowledge to themselves and their actions.	**Workload:** Attendance time: 56 h Self-study time: 214 h
Course: Seminar	2 WLH
Examination: Presentation (approx. 30 min.) with written elaboration (max. 15 pages) **Examination prerequisites:** Regular participation in the seminar as well as successful digital implementation of the given exercises. **Examination requirements:** The students reflect on the results of specific research in image and object science on the contextuality of things and have the ability to evaluate methods and theories and to modify them in approaches. The examination is to be taken in the seminar.	9 C
Course: Exercise	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Langner
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen Module M.Inf.1138: Usable Security and Privacy	5 C 4 WLH
Learning outcome, core skills: On completion of the module, students should be able to: • Understand the needs for usability in secure and privacy-preserving solutions and the associated challenges, • Present and discuss selected themes addressed in the research area of usable security and privacy, • Define and understand the principles and guidelines to apply when designing new solutions, • Describe and compare different methodologies to conduct user studies, • Plan user studies from their design to the processing and presentation of the results.	**Workload:** Attendance time: 56 h Self-study time: 94 h
Course: Usable Security and Privacy (Lecture, Exercise)	4 WLH
Examination: Written exam (90 min.) or oral exam (ca. 20 min.) **Examination requirements:** Introduction to usable security and privacy, selected topics in the research field of usable security and privacy, human-computer interaction principles and guidelines, methods to design and evaluate usable solutions in the area of security and privacy.	5 C

Admission requirements: none	**Recommended previous knowledge:** Backgrounds in Computer Security and Privacy
Language: English	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen Module M.Inf.1139: Privacy-Enhancing Technologies	5 C 4 WLH
Learning outcome, core skills: After successfully completing the module, students are able to: • Define and understand the basic concepts of privacy protection, • Identify and classify the different existing threats against privacy, • Define and understand the legal principles of data protection in Germany, the EU and worldwide, • Explain the principles of fundamental privacy-enhancing technologies as well as define and compare their protection goals, • Understand and analyze selected cutting-edge privacy-enhancing solutions.	**Workload:** Attendance time: 56 h Self-study time: 94 h
Course: Privacy-Enhancing Technologies (Lecture, Exercise)	4 WLH
Examination: Written exam (90 min) or oral exam (approx. 20 min) **Examination requirements:** Privacy threats, data protection legal framework, anonymity, anonymization techniques and services, privacy-enhancing technologies, applied privacy protection.	5 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge in communication networks, databases, and data processing.
Language: English, German	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.Inf.1141: Semistructured Data and XML	6 C 4 WLH
Learning outcome, core skills: Die Studierenden kennen die Konzepte semistrukturierter Datenmodelle und die Parallelen sowie Unterschiede zum "klassischen" strukturierten, relationalen Datenmodell. Sie können damit für eine Anwendung abschätzen, welche Technologien gegebenenfalls zu wählen und zu kombinieren sind. Die Studierenden verfügen über praktische Grundkenntnisse in den üblichen Sprachen dieses Bereiches. Sie haben einen Überblick über die historische Entwicklung von Modellen und Sprachen im Datenbankbereich und können daran wissenschaftliche Fragestellungen und Vorgehensweisen nachvollziehen.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Semistrukturierte Daten und XML (Lecture, Exercise)	
Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 25 Min.) **Examination requirements:** Konzepte semistrukturierter Datenmodelle und die Parallelen sowie Unterschiede zum "klassischen" strukturierten, relationalen Datenmodell; Fähigkeit zur Beurteilung, welche Technologien in einer konkreten Anwendung zu wählen und zu kombinieren sind; praktische Grundkenntnisse in den üblichen Sprachen dieses Bereiches; Überblick über die historische Entwicklung von Modellen und Sprachen im Datenbankbereich; Fähigkeit zum Nachvollziehen wissenschaftlicher Fragestellungen und Vorgehensweisen.	6 C

Admission requirements: Datenbanken	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Wolfgang May
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 100	

Georg-August-Universität Göttingen **Module M.Inf.1142: Semantic Web**	6 C 4 WLH

Learning outcome, core skills: Die Studierenden kennen die theoretischen Grundlagen sowie technischen Konzepte des Semantic Web. Sie können den Nutzen und die Grenzen der verwendeten Technologien einschätzen und in realen Szenarien abwägen. Sie sehen an einigen Beispielen, wo aktuelle wissenschaftliche Fragestellungen ansetzen.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Semantic Web (Lecture, Exercise)	4 WLH
Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 25 Min.) **Examination requirements:** Kenntnisse der theoretischen Grundlagen und technischen Konzepte des Semantic Web; Fähigkeit zum Abschätzen des Nutzens und der Grenzen der verwendeten Technologien; Fähigkeit zur Abwägung realer Szenarien; Fähigkeit zum Nachvollziehen wissenschaftlicher Fragestellungen und Vorgehensweisen.	6 C

Admission requirements: Datenbanken, Formale Systeme	**Recommended previous knowledge:** M.Inf.1243
Language: German, English	**Person responsible for module:** Prof. Dr. Wolfgang May
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module M.Inf.1161: Image Analysis and Image Understanding**	6 C 4 WLH

Learning outcome, core skills: Kompetenz, grundlegende Techniken der Bildverarbeitung sinnvoll zur Auswertung von Bilddaten einzusetzen; Verständnis für Probleme, Methoden und Begrenzungen der Bildanalyse mit elementaren Signalverarbeitungs- und höheren KI-Ansätzen.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Bildanalyse und Bildverstehen (Lecture, Exercise)	4 WLH
Examination: Klausur (120 Min.) oder mündliche Prüfung (ca. 25 Min.) **Examination prerequisites:** Aktive Teilnahme an den Übungen belegt durch die erfolgreiche Bearbeitung von 60 % der Übungszettel **Examination requirements:** Nachweis über den Erwerb vertiefter Kenntnisse und Fähigkeiten: Kompetenz, grundlegende Techniken der Bildverarbeitung sinnvoll zur Auswertung von Bilddaten einzusetzen; Verständnis für Probleme, Methoden und Begrenzungen der Bildanalyse mit elementaren Signalverarbeitungs- und höheren KI-Ansätzen.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Winfried Kurth
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 100	

Georg-August-Universität Göttingen **Module M.Inf.1171: Cloud and Service Computing**	5 C 3 WLH

Learning outcome, core skills:
Successfully completing the module, students understand

- hybrid clouds, consisting of private and public clouds
- basic web technologies (transfer protocols, markup languages, markup processing, RESTful and SOAP web services)
- virtualization technologies (server, storage, and network virtualization)
- data services (sharing, management, and analysis)
- continuous integration/continuous delivery
- container and orchestration in clouds (e.g. Kubernetes, OpenStack Heat)
- monitoring of cloud infrastructures
- interoperability in clouds (e.g. Helm)
- portability and security
- microservices
- cloud computing workloads

On completion of this module students will have a good understanding of the fundamental and up-to-date concepts used in the context cloud computing. This basic knowledge can be leveraged by students to design, implement, and manage service-oriented cloud infrastructures by themselves.

Workload:
Attendance time:
42 h
Self-study time:
108 h

Course: Cloud and Service Computing (Lecture, Exercise) — 3 WLH

Contents:
Cloud Computing is a method of providing shared computing resources, such as applications, computing, storage, networking, development, and deployment platforms. In cloud computing these resources can be delivered as service to the user. Such Service-oriented infrastructures are the backbone of modern IT systems. They pool resources, enable collaboration between people, and provide complex services to end-users. Everybody who uses today's web applications implicitly relies on sophisticated service-oriented infrastructures. The same is true for users of mobile devices such as tablet computers and smart phones, which provide most of their benefits leveraging services.

The key challenges of cloud computing infrastructures are related to scaling services. More specifically large cloud-computing infrastructures require scalability of IT management, programming models, and power consumption. The challenges to scale services lie in the inherent complexity of hardware, software, and the large amount of user requests, which large-scale services are expected to handle. This module teaches methods that address and solve those challenges in practice. Key aspects of the module are the management of IT infrastructures, the management of service landscapes, and programming models for distributed applications.

The module covers the virtualization of computing, storage, and network resources as the fundament for scaling. IT management is covered by the discussion of deployment

models, service level agreements. Programming models are covered by discussing RESTful and SOAP web-services. Both, lectures and exercises, keep a close connection to the practical application of the discussed topics. The practical value of service-oriented infrastructures is highlighted in the context of enterprises as well as in the context of science. The methods taught in this module benefit from the lecturers' experiences at GWDG and thus provide exclusive insights into the topic. After successfully attending these modules students will understand the most important aspects to design, implement, and manage internet-scale cloud computing infrastructures.	
Examination: Written exam (90 min) or oral exam (approx. 30 min) **Examination requirements:** • Hybrid and Multi cloud infrastructures • RESTful and SOAP web services • Compute, storage, and network virtualisation • Infrastructure-as-a-service, platform-as-a-service, software-as-a-service • Characteristics of Cloud computing (NIST) • Service life cycle • Service level agreements • Cloud computing workloads (e.g. batch, SaaS, big data, back-end)	5 C

Admission requirements: none	**Recommended previous knowledge:** • Basic programming skills • Basic knowledge of Linux operating systems
Language: English	**Person responsible for module:** Prof. Dr. Ramin Yahyapour
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 50	

Georg-August-Universität Göttingen Module M.Inf.1185: Sensor Data Fusion	5 C 4 WLH

Learning outcome, core skills:

This module is concerned with fundamental principles and algorithms for the processing and fusion of noisy (sensor) data. Applications in the context of navigation, object tracking, sensor networks, robotics, Internet-of-Things, and data science are discussed.

After successful completion of the module, students are able to

- define the notion of data fusion and distinguish different data fusion levels
- formalize data fusion problems as state estimation problems
- develop distributed and decentralized data fusion architectures
- describe the basic concepts of linear estimation theory
- explain the fundamental formulas for the fusion of noisy data
- deal with unknown correlations in data fusion
- understand the Bayesian approach to data fusion and estimation
- formulate dynamic models for time-varying phenomena
- describe the concept of a recursive Bayesian state estimator
- explain and apply the Kalman filter for state estimation in dynamic systems
- explain and apply basic nonlinear estimation techniques such as the Extended Kalman filter (EKF) and Unscented Kalman filter (UKF)
- assess the properties, advantages, and disadvantages of the discussed (nonlinear) estimators
- explain different approaches to deal with uncertainty such as probability theory, fuzzy theory, and Dempster–Shafer theory
- identify data fusion applications and assess the benefits of data fusion

Workload:
Attendance time:
56 h
Self-study time:
94 h

Course: Sensor Data Fusion (Lecture, Exercise)	4 WLH
Examination: Written exam (90 min.) or oral exam (approx. 20 min.) **Examination requirements:** Definition of data fusion; data fusion levels; formalization of data fusion problems; distributed and decentralized fusion architectures; linear estimation theory; fundamental fusion formulas; dynamic state estimation; Kalman filter; Extended Kalman filter (EKF); Unscented Kalman filter (UKF), algorithms for dealing with unknown correlations; fuzzy theory; Dempster-Shafer theory	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Marcus Baum
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**

Maximum number of students: 50	

Georg-August-Universität Göttingen Module M.Inf.1186: Seminar Hot Topics in Data Fusion and Analytics	5 C 2 WLH
Learning outcome, core skills: After successful completion of the modul students are able to • get acquainted with a specific research topic in the area of data fusion and data analytics • explain the considered problem in the chosen research topic • collect, evaluate, and summarize related work • describe solution approaches for the considered problem • discuss advantages and disadvantages of the proposed approaches • give an outlook to future research directions • prepare and give a presentation about the chosen research topic • write a scientific report about the chosen research topic • follow recent research in data fusion and data analytics	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Hot Topics in Data Fusion and Analytics (Seminar)	2 WLH
Examination: Presentation (approx. 45 minutes) and written report (max. 20 pages) **Examination prerequisites:** Attendance in 80% of the seminar presentations **Examination requirements:** Advanced knowledge of a specific research topic in the field of data fusion and data analytics; written scientific report; oral presentation	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Marcus Baum
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.1188: Mobile Robotics**	5 C 4 WLH

Learning outcome, core skills: This module is concerned with fundamental principles and algorithms for mobile robot navigation and perception. After completion, the students are able to • model the locomotion of wheeled mobile robots • understand the concept of dead reckoning • describe the most common sensors for mobile robots, e.g., inertial sensors and beam-based sensors • employ probabilistic state estimation methods such as Kalman filters and sequential Monte Carlo methods (particle filters) for robot navigation and perception • describe and distinguish different concepts for localization such as trilateration and triangulation • implement and evaluate basic algorithms for localization • understand the robot mapping problem and explain different map representations such as occupancy grids • describe the problem of Simultaneous Localization and Mapping (SLAM) • implement and evaluate basic algorithms for SLAM such as graph-based approaches and Rao-Blackwellized particle filters • implement and evaluate basic feature extraction methods such as Random Sample Consensus (RANSAC) • design basic planning algorithms for mobile robots using, e.g., a Markov Decision Process (MDP)	**Workload:** Attendance time: 56 h Self-study time: 94 h

Course: Mobile Robotics (Lecture, Exercise)	4 WLH
Examination: Written exam (90 min.) or oral exam (approx. 20 min.) **Examination requirements:** Motion models for wheeled robots; dead reckoning; mobile robot sensors; Kalman filter; particle filter; localization concepts and algorithms; robot mapping; Simultaneous Localization and Mapping (SLAM); feature extraction methods; planning algorithms	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Marcus Baum
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.Inf.1191: Privacy in Ubiquitous Computing**	5 C 4 WLH
Learning outcome, core skills: After successful completion of the module, students are able to: • Define and understand the key concepts of privacy and ubiquitous computing, • Identify and classify threats to privacy in ubiquitous computing, • Describe, compare, and choose fundamental techniques to protect privacy, • Understand and analyze cutting-edge solutions.	**Workload:** Attendance time: 56 h Self-study time: 94 h
Course: Privacy in Ubiquitous Computing (Lecture, Exercise)	4 WLH
Examination: Written exam (90 min.) or oral exam (approx. 20 min.) **Examination prerequisites:** Active participation during the exercises. **Examination requirements:** Introduction to privacy and ubiquitous computing, privacy threats, privacy-enhancing technologies, wireless sensor networks, smart meters, participatory sensing, RFIDs, Internet-of-Things.	5 C

Admission requirements: none	**Recommended previous knowledge:** M.Inf.1120, M.Inf.1121
Language: English	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module M.Inf.1193: Seminar on Usable Security and Privacy**	5 C 2 WLH
Learning outcome, core skills: On completion of the module, students should be able to: • Investigate a selected topic related to usability in the field of security and privacy, • Identify relevant publications to address this topic and survey the state-of-the-art, • Understand, present, and explain issues encountered by the users, • Develop and describe new ideas to address these issues, • Summarize their findings in a written report, • Give a presentation about their chosen topic.	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Seminar Usable Security and Privacy (Seminar)	2 WLH
Examination: Presentation (approx. 30 min.) and written report (max. 15 pages) **Examination requirements:** The students shall show that: • They are able to conduct literature research on a topic in the area of usable security and privacy, • They are able to identify, understand, and explain usability issues encountered in this area, • They are able to propose novel solutions to these issues and discuss their potential advantages and limitations, • They are able to write a structured scientific report on their findings by respecting the rules of good scientific practice, • They are able to present and critically discuss their findings in a presentation.	5 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of privacy and usability obtained, e.g., in the recommended lecture “Usable Security and Privacy”
Language: English	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.1194: Seminar on Privacy in Data Science**	5 C 2 WLH
Learning outcome, core skills: On completion of the module, students should be able to: • Investigate selected topics on privacy in data science, • Identify existing solutions in the area to be investigated, • Explain, compare, and discuss these solutions, • Develop new ideas to improve the current state-of-the-art, • Summarize their findings in a written report, • Give a presentation about the chosen area.	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Seminar Privacy in Data Science (Seminar)	2 WLH
Examination: Presentation (approx. 30 min.) and written report (max. 15 pages) **Examination requirements:** The students shall show that: • They are able to conduct literature research on a topic in the area of privacy in data science, • They are able to explain selected solutions related to the chosen topic, • They are able to compare these solutions by analyzing their potential advantages and limitations, • They are able to write a structured scientific report on their findings by respecting the rules of good scientific practice, • They are able to present and critically discuss their findings in a presentation.	5 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of privacy obtained, e.g., in one of the recommended lectures “Privacy-Enhancing Technologies”, “Privacy in Ubiquitous Computing”, “Usable Security and Privacy”, or “Ethical, Social, and Legal Foundations of Data Science”.
Language: English	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.1195: Seminar Human in the Age of Artificial Intelligence**	5 C 2 WLH
Learning outcome, core skills: This seminar investigates the relationship between Artificial Intelligence and automation and the human, the future of humanity, and ethical decision-making. This will be achieved by research and review of literature about the topic. On completion of this module students : • are familiar with the main concepts of the designed course and develop a greater awareness of the benefits and limitations of AI applications. • understand the role of artificial intelligence on Self and in Society. • are able to write a report demonstrating their understanding of the topic. • have improved their presentation skills on the selected topic. • have improved their ability to work independently in a pre-defined context.	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Human in the Age of Artificial Intelligence (Seminar)	2 WLH
Examination: Presentation (approx. 45 minutes) and written report (max. 15 pages) **Examination requirements:** The students shall show that: • they are able to become acquainted with the topic of the designed course by investigating research publications • they are able to assess and analyze the research on the chosen topic • they are able to present and discuss their finding in a presentation • they are able to write a scientific report according to good scientific practice	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Parisa Memarmoshrefi
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.1211: Probabilistic Data Models and Applications**	6 C 4 WLH
Learning outcome, core skills: In dem Modul erwerben Studierende spezialisierte Kenntnisse zu Auswahl, Entwurf und Anwendungen von Modellen, für die die (parametrisierte) Zufälligkeit der Daten eine wesentliche Komponente der Modellierung ist. Überblick über die Modulinhalte: Zu verarbeitende Daten in verschiedensten Anwendungsbreichen (z. B. Bioinformatik) unterliegen meist statistischen Gesetzmäßigkeiten. Das Modul ist fokussiert auf Methoden zur Erkennung und algorithmischen Ausnutzung solcher typischen Muster durch geeignete probabilistische Modellierung der Daten und auf die Schätzung der Modellparameter. z. B. Vorlesung Algorithmisches Lernen, Vorlesung Datenkompression und Informationstheorie, Probabilistische Datenmodelle in der Angewandten Informatik.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Vorlesungen, Übungen und Seminare zu den vorgenannten Themen	
Examination: Klausur (60 Min.) oder mündliche Prüfung (ca. 20 Min.) **Examination requirements:** Nachweis über den Erwerb spezialisierter Kenntnisse und Fähigkeiten zu probabilistischen Datenmodellen, der Komplexität ihrer algorithmischen Unterstützung und ggf. ihrer Anwendung in einer der Angewandten Informatiken oder einem Anwendungsbereich.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.Inf.1213: Algorithmic Learning and Pattern Recognition	6 C 4 WLH
Learning outcome, core skills: Es werden spezialisierte Kompetenzen im Bereich des algorithmischen Lernens und der Mustererkennung vermittelt. Verständnis der theoretischen Grundlagen und der Probleme bei praktischen Anwendungen.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Algorithmisches Lernen (Lecture, Exercise) *Contents*: Es werden die Grundlagen des Algorithmischen Lernens vermittelt, prinzipielle Schranken und Möglichkeiten aufgezeigt und einige spezielle Ansätze diskutiert wie z. B. Grundlagen des PAC-Lernens und des PAC-Lernens mit Rauschen auf der Klassifikation. Schlüsselbegriffe wie VC Dimension und Rademacher-Komplexität von Hypothesenklassen die es ermöglichen, sowohl Möglichkeiten als auch Grenzen der Lernbarkeit zu verstehen.	4 WLH
Examination: Klausur (60 Min.) oder mündliche Prüfung (ca. 20 Min.) **Examination requirements:** Nachweis über den Erwerb spezialisierter anwendungsorientierter Kenntnisse und Kompetenzen aus dem Bereich des algorithmischen Lernens und der Mustererkennung.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen Module M.Inf.1232: Parallel Computing	6 C 4 WLH

Learning outcome, core skills:

Successfully completing the module, students are able to:

- define and describe the benefit of parallel computing
- specify the classification of parallel computers (Flyn classification)
- analytically evaluate the performance of parallel computing approaches (scaling/ performance models)
- know the parallel hardware and performance improvement approaches (cache coherence, pipeline, etc.)
- know the interconnects and networks and their role in parallel computing
- understand and develop sample parallel programs using different paradigms and development environments (e.g., shared memory and distributed models)
- expose to some applications of Parallel Computing through hands-on exercises

Workload:
Attendance time:
56 h
Self-study time:
124 h

Course: Parallel Computing (Lecture, Exercise) — 4 WLH

Contents:

Successfully completing the lecture, students are able to:

- define and describe the benefit of parallel computing and identify the role of software and hardware in parallel computing
- specify the Flynn classification of parallel computers (SISD, SIMD, MIMD)
- analytically evaluate the performance of parallel computing approaches (Scaling/ Performance models)
- understand the different architecture of parallel hardware and performance improvement approaches (e.g., caching and cache coherence issues, pipeline, etc.)
- define Interconnects and networks for parallel computing
- architecture of parallel computing (MPP, Vector, Shared memory, GPU, Many-Core, Clusters, Grid, Cloud)
- design and develop parallel software using a systematic approach
- parallel computing algorithms and development environments (i.e. shared memory and distributed memory parallel programming)
- write parallel algorithms/programs using different paradigms and environments (e.g., POSIX Multi-threaded programming, OpenMP, MPI, OpenCL/CUDA, MapReduce, etc.)
- get exposed to some applications of Parallel Computing through exercises

References

- An Introduction to Parallel Programming, Peter S. Pacheco, Morgan Kaufmann (MK), 2011, ISBN: 978-0-12-374260-5.
- Designing and Building Parallel Programs, Ian Foster, Addison-Waesley, 1995, ISBN 0-201-57594-9 (Available online).

• Advanced Computer Architecture: Parallelism, Scalability, Programmability, Kai Hwang, Int. Edition, McGraw Hill, 1993, ISBN: 0-07-113342-9. • In addition to the mentioned text book, tutorial and survey papers will be distributed in some lectures as extra reading material.	
Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.) **Examination requirements:** Parallel programming; Shared Memory Parallelism; Distributed Memory Parallelism, Single Instruction Multiple Data (SIMD); Multiple Instruction Multiple Data (MIMD); Hypercube; Parallel interconnects and networks; Pipelining; Cache Coherence; Parallel Architectures; Parallel Algorithms; OpenMP; MPI; Multi-Threading (pthreads); Heterogeneous Parallelism (GPGPU, OpenCL/CUDA)	6 C

Admission requirements: • Data structures and algorithms • Programming in C/C++	**Recommended previous knowledge:** • Computer architecture • Basic knowledge of computer networks and topologies
Language: English	**Person responsible for module:** Prof. Dr. Ramin Yahyapour
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 50	

Georg-August-Universität Göttingen Module M.Inf.1234: Emerging Topics in Advanced Computer Networks	6 C 4 WLH
Learning outcome, core skills: This course covers the principles of existing and emerging advanced networking technologies and services e.g., ICN, SDN, Smart City, IoT, Advanced Networking. In general, students will study computer networks, future Internet architectures and data science related topics. The students will • know the principles of existing and emerging advanced networking technologies and services • have a basic understanding of computer networks • have been introduced to the state-of-the-art research in the relevant field • build a practical system based on the study material covered in the course	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Emerging Topics in Advanced Computer Networks (Lecture, Exercise)	4 WLH
Examination: Oral exam (approx. 30 min) or written exam (90 min) **Examination requirements:** Advanced networking technologies, Peer-to-Peer networks, Data science, state-of-the-art research in the computer networks field	5 C

Admission requirements: none	**Recommended previous knowledge:** • Basic knowledge in computer networks and data science • Basics knowledge of algorithms and data structures • Basic programming skills
Language: English	**Person responsible for module:** Prof. Dr. Xiaoming Fu
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module M.Inf.1236: High-Performance Data Analytics**	6 C 4 WLH

Learning outcome, core skills: Successfully completing the module, students understand • the motivation and use-case for large-scale data analytics • performance implications of hardware and software system for large-scale data workloads • the usage of industry-standard tools to solve data analytics problems • algorithms, data structures, data models, tools, and infrastructure for efficient processing of data	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: High-Performance Data Analytics (Lecture, Exercise) *Contents*: Data-driven science requires the handling of large volumes of data in a quick period of time. Executing efficient workflows is challenging for users but also for systems. This module introduces concepts, principles, tools, system architectures, techniques, and algorithms toward large-scale data analytics using distributed and parallel computing. We will investigate the state-of-the-art of processing data of workloads using solutions in High-Performance Computing and Big Data Analytics. Topics cover: • Challenges in high-performance data analytics • Use-cases for large-scale data analytics • Performance models for parallel systems and workload execution • Data models to organize data and (No)SQL solutions for data management • Industry relevant processing models with tools like Hadoop, Spark, and Paraview • System architectures for processing large data volumes • Relevant algorithms and data structures • Visual Analytics • Parallel and distributed file systems Guest talks from academia and industry will be incorporated in teaching that demonstrates the applicability of this topic. Weekly laboratory practicals and tutorials will guide students to learn the concepts and tools. In the process of learning, students will form a learning community and integrate peer learning into the practicals. Students will have opportunities to present their solutions to the challenging tasks in the class. Students will develop presentation skills and gain confidence in the topics.	4 WLH
Examination: Written exam (90 min) or oral exam (approx. 30 min) **Examination requirements:** • Challenges in high-performance data analytics • Use-cases for large-scale data analytics • Performance models for parallel systems and workload execution • Data models to organize data and (No)SQL solutions for data management • Industry relevant processing models with tools like Hadoop, Spark, and Paraview	6 C

• System architectures for processing large data volumes • Relevant algorithms and data structures • Visual Analytics • Parallel and distributed file systems	

Admission requirements: none	**Recommended previous knowledge:** Basic programming skills, Basic knowledge of Linux operating systems, Python
Language: English	**Person responsible for module:** Prof. Dr. Julian Kunkel
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module M.Inf.1237: Seminar Newest Trends in High-Performance Data Analytics**	5 C 2 WLH

Learning outcome, core skills: High-Performance Data Analytics is a vehicle to extract findings from large data sets. It is an indispensable tool in science and business but a rapidly changing field. As part of this seminar, you will create a presentation and report revolving around a selected hot topic in German or English. You will learn to research literature and may conduct small experiments to provide a holistic view of the selected topic. You will meet regularly with an assigned supervisor and work towards the presentation and report. The students will be able to • Appraise research in the area of high-performance data analytics • Compose a presentation covering their selected topic in depth • Evaluate findings (tools or theory) of other researchers • Explain theory and application covering their topic	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Seminar Newest Trends in High-Performance Data Analytics (Seminar)	2 WLH
Examination: Presentation (approx. 35 min.) and report (max. 15 pages) **Examination prerequisites:** Participation in the seminar	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** Prof. Dr. Julian Kunkel
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 40	

Georg-August-Universität Göttingen **Module M.Inf.1244: Seminar on optimal transport**	5 C 2 WLH

Learning outcome, core skills: By using original references students will familiarize themselves with advanced aspects of optimal transport theory or its applications in modern data analysis and machine learning and present their findings to the other participants. • read and understand original research papers or graduate-level textbooks • collect background material on a given topic and its context • order and prioritize this material for a presentation • prepare a structured presentation with a corresponding handout • give an accessible presentation • answer questions from the audience that may go slightly beyond the presentation material • leading and participating in a scientific discussion	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Seminar on optimal transport (Seminar)	2 WLH
Examination: Presentation (approx. 45 min.), follow-up discussion, and handout (max. 5 pages) **Examination requirements:** Advanced knowledge on a specific topic in optimal transport research; structured presentation; handout	5 C

Admission requirements: none	**Recommended previous knowledge:** Lecture “Computational optimal transport” or some course on optimization are strongly recommended.
Language: English	**Person responsible for module:** Prof. Dr. Bernhard Schmitzer
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.1268: Information Theory**	6 C 4 WLH

Learning outcome, core skills: Die Studierenden • kennen die mathematische Grundlagen der Informationstheorie • beherschen die grundlegenden Begriffe der Informationstheorie • beherrschen die zentralen Begriffe und Verfahren der Datenkompression • kennen grundlegende Begriffe und Aussagen zur Kanalkapazität • kennen grundlegende Begriffe und Aussagen zur Kolmogorov-Komplexität	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Elements of Information Theory (Lecture, Exercise)	4 WLH
Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.) **Examination prerequisites:** Bearbeitung von 50% aller Übungsblätter, Vorführung mindestens einer Aufgabe während der Übung, kontinuierliche Teilnahme an den Übungen **Examination requirements:** In der Prüfung wird die aktive Beherrschung der vermittelten Inhalte und Techniken nachgewiesen, z.B. • Kenntnisse von Grundbegriffen wie Entropie, relative Entropie, wechselseitige Information • asymptotische Äquipartitionseigenschaft und Typtheorie • Entropierate stochastischer Prozesse • Grundlagen der Datenkompression einschließlich ihrer Bezüge zur Spieltheorie • Kanalkapazität und Kanalcodierungssatz • Grundbegriffe der Kolmogorov-Komplexität	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Stephan Waack
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.Inf.1303: Imaging and Visualization**	6 C 4 WLH
Learning outcome, core skills: The students • name and describe aims and typical tasks in medical imaging and image processing and explain the corresponding challenges. • name the relevant imaging techniques in medicine and explain their essential characteristics. • describe essential mathematical and physical contexts - on an appropriate level - which are the basis for the introduced imaging techniques. • name and describe established memory formats, transfer processes, and compression technologies for medical imaging data and substantiate reasons for their implementation. • explain the fundamentals of image enhancement in time and frequency domain. • explain essential processes in image segmentation and description. • explain fundamentals of object identification and classification. • apply the theoretical fundamentals in practical use cases with established software tools.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Imaging and Visualization (Block course, Lecture, Exercise, Seminar) *Contents*: Radiological, nuclear-medicine, and optical procedures in medicine; requirements and legal frameworks, image formats, transfer and storage, compression; digital image representation, processing chain, resolution and contrast, contrast enhancement, noise reduction, filter techniques; detection of points, lines, edges, and segments, threshold and area-oriented operations, feature extraction; use of tools such as Python, Matlab, OpenCV. The contents are adjusted to current developments. Literature is indicated at the start of each semester.	4 WLH
Examination: Written Evaluation (Klausur), E-Assessment resp. (120 minutes.) or oral evaluation (ca. 30 minutes.) **Examination prerequisites:** Regular attendance in seminar dates.	6 C
Examination requirements: In the evaluation, the theoretical knowledge of essential terms and methods as well as their choice, implementation, and assessment is tested in case examples. In written evaluations and e-assessments, tasks are generally given in open questions and are to be answered accordingly, other question types (such as MC) may be used in minor part.	

Admission requirements: none	**Recommended previous knowledge:** Students are expected to have sound knowledge in fundamentals of mathematics.
Language: English, German	**Person responsible for module:** Prof. Dr. rer. nat. Dagmar Krefting

	Prof. Dr. Ulrich Sax
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.Inf.1304: E-Health**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Die Studierenden können die verschiedenen Kommunikationsstandards im Gesundheitswesen beschreiben und bewerten. Sie können die bisherige Entwicklung dieser Standards beschreiben und zukünftige Herausforderungen und Potentiale von Standards darlegen. Die Studierenden können die Bedeutung der Standards in der aktuellen Forschung beschreiben. Die Studierenden können die wesentlichen rechtlichen Rahmenbedingungen der E-Health benennen. Sie können die Bedeutung der nationalen und internationalen Verordnungen und Gesetze erläutern und geeignete Beispiele nennen. Die Studierenden können die Auswirkungen der E-Health auf die traditionelle Organisationsform des deutschen Gesundheitswesens beschreiben und Chancen und Herausforderungen der digitalen Transformation erläutern.	Attendance time: 56 h Self-study time: 124 h

Course: E-Health (Block course)	4 WLH
Contents: Kommunikationsstandards im Gesundheitswesen und deren bisherige und zukünftige Entwicklung; Bedeutung der Standards in der aktuellen Forschung; rechtliche Rahmenbedingungen der E-Health (nationale und internationale Verordnungen und Gesetze); Auswirkungen der E-Health auf das deutsche Gesundheitswesen; Chancen und Herausforderungen der digitalen Transformation; weitere Inhalte nach aktueller Entwicklung. Literaturempfehlungen werden zu Beginn des Semesters ausgegeben.	
Examination: Klausur bzw. E-Prüfung (90 Min.) oder mündliche Prüfung (ca. 20 Min.) (50%); Seminararbeit (min. 10 bis max. 20 Seiten) (25%) und Seminarvortrag (30 bis max. 45 Minuten) (25%). **Examination prerequisites:** Teilnahme an den Blockseminarterminen.	6 C

Examination requirements:	
In der Prüfung wird neben dem theoretischen Verständnis zentraler Begriffe und Methoden deren Auswahl, Einsatz und Überprüfung anhand von Fallbeispielen nachgewiesen. Lernziele werden zu jeder Lehreinheit ausgegeben. Prüfungsanforderungen werden in der Lehrveranstaltung durch geeignete Übungsaufgaben und/oder Repetitorien vermittelt. In Klausuren bzw. E-Prüfungen sind grundsätzlich offene Fragen in Textform zu bearbeiten, weitere Fragetypen (z. B. MC) sind in geringem Umfang möglich. Prüfungsanforderungen in Seminarvorträgen und Hausarbeiten sind einer schriftlichen Aufgabenstellung zu entnehmen, Bewertungskriterien werden zu Beginn des jeweiligen Semesters ausgegeben.	

Admission requirements: keine	**Recommended previous knowledge:** keine
Language: German, English	**Person responsible for module:** Prof. Dr. rer. nat. Dagmar Krefting

	Prof. Dr. Ulrich Sax
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.Inf.1307: Current Topics in Medical Informatics**	6 C 4 WLH
Learning outcome, core skills: The students • name and describe topics in medical informatics, which are of major importance for the future development of the field. • explain, discuss, and substantiate said importance. • reflect on a topic and analyze it by means of literature research. • conduct topic-related assignments and case examples. • present and discuss their results.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Current Topics in Medical Informatics (Block course, Lecture, Exercise, Seminar) *Contents*: The contents are adjusted to current developments of the field. Examples: clinical decision support, assistive health care technologies, advanced technologies and methods of data analysis and data quality management, machine learning, semantic analysis of medical data models. The seminar can be conducted as an online course.	4 WLH
Examination: Seminar paper (max. 20 pages) (60%) and presentation (ca. 20 minutes) (40%) or e-assessment in the online-course (100 %) **Examination prerequisites:** Regular participation in the seminar.	6 C
Examination requirements: Detailed coverage of a current topic in medical informatics in accordance with the learning aims. Requirements of seminar presentations and papers are specified in assignments, as are requirements in the e-assessment. Grading criteria are conveyed at the start of each semester.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** Prof. Dr. rer. nat. Dagmar Krefting Prof. Dr. Ulrich Sax
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.Inf.1308: Journal Club**	3 C 2 WLH

Learning outcome, core skills: The students • conduct their own research of current scientific journal publications in a given area of medical informatics. • choose relevant publications and justify their choice. • research background information on publication sources and authors and put it into the scientific context of the given area of the field. • read, present, assess, and discuss scientific publications.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Journal Club (Seminar) *Contents*: Contents are adjusted to the current development of the field.	2 WLH
Examination: Two seminar presentations (ca. 30 minutes each) (40% each) and active participation in the discussions of papers presented by other candidates (20%). **Examination prerequisites:** Evidence of active participation in at least 12 seminar dates.	3 C

Examination requirements: Evidence of acquired, field-specific competencies through critical examination of relevant publications. Requirements of seminar presentations are specified in assignments. Grading criteria are conveyed at the start of each semester.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. rer. nat. Dagmar Krefting Prof. Dr. Ulrich Sax
Course frequency: each semester	**Duration:** 2 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 25	

Georg-August-Universität Göttingen Module M.Inf.1351: Work Methods in Health Research	5 C 3 WLH
Learning outcome, core skills: Die Studierenden kennen Methoden, Aufbau und Ziele kollaborativer, IT-unterstützter Arbeitsorganisationen und verstehen ihre Bedeutung im globalen Forschungs- und Gesundheitsmarkt. Sie kennen die Methoden zur Bearbeitung wissenschaftlicher Projekte und können deren Ergebnisse präsentieren.	**Workload:** Attendance time: 42 h Self-study time: 108 h
Course: Mögliche Lehrformen: Vorlesung, Übung, Seminar, Blockseminar *Contents*: Werden ständig den aktuellen Entwicklungen dieses dynamischen Gebietes angepasst. Beispiele: Grundlagen und Arbeitsmethoden in Forschung und Projektarbeit. Kollaborative Arbeitsmethoden in der Forschung: Vorlesung und Seminar	
Examination: Hausarbeit (max. 20 Seiten) und Vortrag (ca. 20 Minuten) **Examination prerequisites:** regelmäßige Teilnahme bei Blockseminaren und bei Seminaren **Examination requirements:** Die Studierenden können die Bedeutung kollaborativer, IT-unterstützter Arbeitsorganisationen im globalen Forschungs- und Gesundheitsmarkt, sowie deren Methoden und Aufbau beschreiben. Sie können wissenschaftlicher Projekte bearbeiten und deren Ergebnisse präsentieren.	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. med. Otto Rienhoff
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1
Maximum number of students: 25	

Georg-August-Universität Göttingen Module M.Inf.1501: Data Mining in Bioinformatics	6 C 4 WLH
Learning outcome, core skills: Die Studierenden lernen Methoden zur Analyse mehrdimensionaler Daten, die eine entscheidende Rolle bei der Erforschung biologischer Systeme spielen. Ziel ist das Verständnis der besonderen Eigenschaften von hochdimensionalen Räumen und der statistischen Methoden mit denen Strukturen in komplexen Daten explizit gemacht werden können. Kriterien für die Auswahl und Anwendbarkeit verschiedener Verfahren sollen theoretisch und praktisch nachvollzogen werden.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Data Mining in der Bioinformatik (Lecture)	2 WLH
Course: Rechnerübung zu Data Mining in der Bioinformatik (Block course)	2 WLH
Examination: Oral examination (approx. 20 minutes)	6 C
Examination requirements: Die Studierenden sollen nach Abschluss des Moduls in der Lage sein, Methoden zur Analyse von komplexen Daten selbständig zu verstehen und anzuwenden, sowie die Grenzen der Anwendbarkeit kritisch zu beurteilen.	

Admission requirements: none	**Recommended previous knowledge:** Algorithmen der Bioinformatik, Maschinelles Lernen in der Bioinformatik
Language: German, English	**Person responsible for module:** Dr. Peter Meinicke
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.Inf.1503: Seminar Bioinformatics	5 C 2 WLH
Learning outcome, core skills: Die Studierenden sollen lernen sich anhand von Originalarbeiten selbstständig in aktuelle Themen der Bioinformatik einzuarbeiten und den erarbeiteten Stoff vor einem kritischen Publikum vorzutragen. Hierzu gehört das gründliche Durcharbeiten und Beurteilen der betreffenden Originalarbeit sowie die Erarbeitung von Grundlagen, die für das Verstehen der Arbeit notwendig sind, dort aber aus Platzgründen nicht ausgeführt sind. Dabei sind im allgemeinen weitere Originalarbeiten oder Lehrbücher heranzuziehen, die notwendig sind, um die gewählte Originalarbeit vollständig zu verstehen und die gewonnenen Erkenntnisse anwenden zu können.	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Literaturseminar Bioinformatik (Seminar) *Contents*: Aktuelle Forschungsarbeiten der Bioinformatik	2 WLH
Examination: Vortrag (ca. 60 Min.) mit schriftlicher Ausarbeitung (max. 10 Seiten)	5 C
Examination requirements: Da im Vortrag nur ein Teil des erarbeiteten Stoffs dargestellt werden kann, ist eine sinnvolle Auswahl zu treffen. Die Unterscheidung zwischen wichtigen und weniger wichtigen Bestandteilen des erlernten Stoffs gehört zu den Aufgaben des Vortragenden. Es wird erwartet, dass der Vortragende nicht nur den vorgetragenen Stoff beherrscht, sondern auch Grundlagen dieses Stoffs, die im Vortrag aus Zeitgründen nicht behandelt werden konnten. Schließlich ist eine schriftliche Zusammenfassung des Vortrags zu erstellen und eine exemplarische Anwendung zu dokumentieren. Die Prüfungs besteht aus Vortrag mit schriftlicher Ausarbeitung inkl. Dokumentation einer Anwendung.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Burkhard Morgenstern
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Inf.1504: Algorithms in Bioinformatics II**	6 C 4 WLH

Learning outcome, core skills: Die Studierenden erlernen Algorithmen zur Clusteranalyse und zur Analyse von RNA-Strukturen, Genvorhersage bei Eukaryoten, Mustererkennung auf Sequenzen und fortgeschrittene Methoden des Sequenzalignments.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Algorithmen der Bioinformatik II (Lecture, Exercise)	4 WLH
Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Die Studierenden sollen nach Absolvierung des Moduls befähigt sein, bekannte Verfahren aus der Informatik für bioinformatische Fragestellungen anzuwenden und die Grenzen der Anwendbarkeit kritisch zu beurteilen.	

Admission requirements: none	**Recommended previous knowledge:** Grundlegende Kenntnisse aus den Bereichen Algorithmen der Bioinformatik, Maschinelles Lernen in der Bioinformatik und Molekularbiologie
Language: German, English	**Person responsible for module:** Prof. Dr. Burkhard Morgenstern
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.Inf.1806: Seminar and Project Databases	6 C 2 WLH
Learning outcome, core skills: Die Studierenden können sich in ein Spezialgebiet moderner Datenbank- und Informationssysteme einarbeiten, Quellen und Dokumentationen im Web suchen und in Beziehung zu dem behandelten Gebiet setzen, Werkzeuge evaluieren sowie in einer Diskussion darstellen und bewerten.	**Workload:** Attendance time: 28 h Self-study time: 152 h
Course: Projektseminar Datenbanken und Informationssysteme	
Examination: Vortrag (ca. 60 Min.) mit schriftlicher Ausarbeitung (max. 25 Seiten) **Examination requirements:** Nachweis über den Erwerb vertiefter Kenntnisse und Fähigkeiten in einem Spezialgebiet moderner Datenbank- und Informationssysteme. Insbesondere zur Darstellung und Bewertung von Quellen, Dokumentationen und Werkzeugen. Der Vortrag umfasst eine Präsentation einer Fallstudie.	6 C

Admission requirements: Datenbanken	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Wolfgang May
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 16	

Georg-August-Universität Göttingen **Module M.Inf.1808: Practical Course on Parallel Computing**	6 C 4 WLH

Learning outcome, core skills: Successfully completing the module, students are able to: • practically work with a cluster of computers (e.g., using a batch system) • practically utilize grid computing infrastructures and manage their jobs (e.g., Globus toolkit) • apply distributed memory architectures for parallelism through practical problem solving (MPI programming) • utilize shared memory architectures for parallelism (e.g., OpenMP and pthreads) • utilize heterogenous parallelism (e.g., OpenCL, CUDA and general GPU programming concepts) • utilize their previous knowledge in data structures and algorithms to solve problems using their devised (or enhanced) parallel algorithms	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Practical Course on Parallel Computing (Practical course) *Contents*: As a practical course, the focus will be on the hands-on session and problem solving. Students will get a brief introduction to the topic and then will use the laboratory equipment to solve assignments of each section of the course.	4 WLH
Examination: Oral examination (approx. 20 minutes), not graded **Examination requirements:** • understand how to manage computing jobs using a cluster of computers or using grid computing facilities • understand the configuration of a PBS cluster through practical assignments • practically use LRM clusters and POVRay examples • understand cluster computing related topics (error handling, performance management, security) in more depth and using hands-on experience and practically using Globus toolkit • design and implement solutions for parallel programs using distributed memory architectures (using MPI) • design and implement solutions for parallel programs using shared memory parallelism (using OpenMP, pthreads) • practically work with MapReduce programming framework and problem solving using MapReduce • practically work with heterogenous parallelism environment (GPGPU, OpenCL, CUDA, etc.)	6 C

Admission requirements: • Data structures and algorithms • Programming in C(/C++)	**Recommended previous knowledge:** • Parallel Computing • Computer architecture • Basic knowledge of computer networks • Basic know-how of computing clusters

Language: English	**Person responsible for module:** Prof. Dr. Ramin Yahyapour
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.Inf.1822: Practical Course in Data Fusion**	6 C 4 WLH
Learning outcome, core skills: After successful completion of the module, students are able to • become acquainted with software tools and frameworks for data fusion • work with modern sensors • collect, process and analyze (sensor) data • implement data fusion algorithms • experimentally evaluate and compare data fusion algorithms • apply data fusion algorithms in the context of localization, navigation, tracking, sensor networks and robotics	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Practical Course in Data Fusion (Practical course)	4 WLH
Examination: Practical project in small groups, oral presentation of results (approx. 15 minutes each), scientific report (max. 6 pages each), not graded **Examination requirements:** Implementation and evaluation of data fusion algorithms, oral presentation, scientific writing and teamwork.	6 C

Admission requirements: none	**Recommended previous knowledge:** M.Inf.1185 or M.Inf.1188
Language: English	**Person responsible for module:** Prof. Dr. Marcus Baum
Course frequency: non-periodic	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.Inf.1828: Lab Usable Security and Privacy	6 C 4 WLH
Learning outcome, core skills: On completion of the module, students should be able to: • Identify, understand, and analyze usability issues in the field of security and privacy, • Design, plan, and conduct a user study to explore a selected issue by following the data protection regulations and taking into account ethical aspects, • Document, analyze, and critically discuss the obtained results, • Propose future improvements or directions based on the obtained results, • Present the study design, methodology, results, and consequences in a written report, • Give a presentation about their study and the associated findings.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Lab Usable Security and Privacy (Practical course)	4 WLH
Examination: Presentation (approx. 20 min.) und written report (max. 15 pages) **Examination requirements:** The students shall show that: • They are able to conduct literature research and analyse the issues related to the usability of security and privacy solutions, • They are able plan and conduct a user study from its design to the processing and presentation of the results, • They are able to write a structured scientific report on their study including its design and the obtained results by respecting the rules of good scientific practice and data protection regulations, • They are able to present both their study and the associated results as well as critically discuss them in a presentation.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of privacy and usability obtained, e.g., in the recommended lecture “Usable Security and Privacy”
Language: English	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen Module M.Inf.1829: Practical course in High-Performance Computing	6 C 4 WLH

Learning outcome, core skills: This practical course is comprised of two parts: firstly, a crash course on the basics of High-Performance Computing is delivered during a one-week tutorial. In a hands-on experience, it covers the theoretical knowledge regarding parallel computing, high-performance computing, supercomputers, and the development and performance analysis of parallel applications. Practical demonstrations encourage you to utilize the GWDG cluster system to execute existing parallel applications, to start developing your own parallel application using MPI and OpenMP, and to analyze the performance of these applications to ensure they run efficiently. During this week, we will use group works and small exercises to foster the training. We will start forming a learning community that will blend into the second part of the course. Equipped with this experience, in the second part, you will team up in groups of two and parallelize a non-trivial problem of your choice. Firstly, you will decide upon a problem you like to solve, then you create a sequential solution to this problem, and lastly, you apply the experience of the block course to parallelize and analyze the scalability of the application. The results will be shared with the peers in a presentation at the end of the term, and documented in a report - these components will be assessed and marked. The students will be able to • Construct parallel processing schemes from sequential code using MPI and OpenMP • Justify performance expectations for code snippets • Sketch a typical cluster system and the execution of an application • Characterize the scalability of a parallel application based on observed performance numbers • Analyze the performance of a parallel application using performance analysis tools • Describe the development and executions models of MPI and OpenMP • Construct small parallel applications that demonstrate features of parallel applications • Demonstrate the usage of an HPC system to load existing software packages and to execute parallel applications and workflows • Demonstrate the application of software engineering concepts	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Practical course in High-Performance Computing (Block course)	4 WLH
Examination: Presentation (approx. 15 min.) and report (max. 15 pages) for the own project **Examination prerequisites:** Participation in the block seminar **Examination requirements:**	6 C

Successful completion of the own project	

Admission requirements: none	**Recommended previous knowledge:** • Programming experience in C++, C or Python • Parallel programming concepts • Linux
Language: English, German	**Person responsible for module:** Prof. Dr. Julian Kunkel
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 40	

Georg-August-Universität Göttingen Module M.Inf.2001: Python for Data Scientists	3 C 2 WLH
Learning outcome, core skills: After completing the course, students • know fundamental concepts of Python like data types, control flow, functions, classes or exceptions • understand Python modules and are able to create them • have an overview of fundamental modules for data science • know libraries for data presentation • have a basic understanding of software versioning • made hands-on experience with Jupyter notebooks	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Python for Data Scientists (Block course) *Course frequency:* each winter semester	2 WLH
Examination: Practical examination **Examination requirements:** To conduct the exam, students need to know the basic concepts of Python, have to be able to code simple data science assignments, and have to apply Python modules.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Hon.-Prof. Dr. Philipp Wieder
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.Inf.2101: Best Practice Methods of Privacy and Ethics in Data Science**	5 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students • understand the basic foundations of philosophy of science and methods of data science • can critically reflect data science methods with respect to their ethical, social and legal implications • recognize possible consequences of the collection, processing, storage, management and release of data and are familiar with approaches for mitigating the resulting risks • are aware of issues related to equity and diversity in data science and are able to promote equity and diversity • are familiar with the legal framework in Europe regarding privacy, data security, intellectual property and copyright	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Best Practice Methods of Privacy and Ethics in Data Science (Lecture, Seminar)	2 WLH
Examination: Oral presentation (approx. 15 min.) and term paper (max. 10 pages) **Examination requirements:** Applied ethics, ethical and legal frameworks, privacy and data protection, anonymity, data ownership, user consent, data collection, data processing, data storage, data management, data sharing, equity and diversity.	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Heike Bickeböller Dr. Valentin Gold
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 3

Georg-August-Universität Göttingen **Module M.Inf.2102: Advanced Statistical Learning for Data Science**	6 C 4 WLH

Learning outcome, core skills: Students will • learn concepts of advanced statistical methods and their scope of applications. These methods comprise the EM algorithm, Markov models, Hidden Markov Models, Markov chain Monte Carlo. • gain a solid understanding of ensemble learning algorithms. In particular, we will address additive tree approaches like boosting and Random Forest algorithms, as well as methods for ensemble optimization • learn strategies for model assessment and selection such as nested cross-validation, Monte Carlo validation, or permutation tests. Moreover, this will comprise measures of model quality and robustness. • acquire practical experience in the interpretation of machine learning models and learn required methods for feature selection, importance, stability, and robustness • learn techniques of statistical network inference, their implementation as well as their application to high-dimensional data.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Advanced Statistical Learning for Data Science (Lecture) Hastie, et al. Elements of Statistical Learning https://web.stanford.edu/~hastie/ElemStatLearn/ Bishop: Pattern Recognition and Machine Learning. https://cs.ugoe.de/prml	2 WLH
Examination: Written exam (90 min) or oral exam (approx. 20 min) **Examination prerequisites:** M.Inf.2102.Ex: At least 50% of homework exercises solved. **Examination requirements:** Knowledge of advanced statistical methods, ensemble learning, model assessment, and interpretation as well as statistical network inference. Evaluate their advantages and disadvantages and the ability to implement and interpret the results of these techniques.	6 C

Course: Statistical Learning in Data Science Exercise (Exercise)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of linear algebra and probability Completion of B.Inf.1236 Machine Learning or equivalent
Language: English	**Person responsible for module:** Dr. Anne-Christin Hauschild; Dr. Michael Altenbuchinger
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3

Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.Inf.2201: Probabilistic Machine Learning**	6 C 4 WLH

Learning outcome, core skills: After successful completion of the module, students • know the basic principles and tools of probabilistic reasoning • have gained a deeper knowledge about popular algorithms and techniques in probabilistic machine learning • have gained an intuitive and mathematical understanding of algorithmic reasoning with uncertainty • have acquired a basic toolbox of algorithms and methods for various problem classes • become proficient in implementing and debugging probabilistic algorithms	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Probabilistic Machine Learning (Lecture)	2 WLH
Examination: Written examination (90 min), in case of low number of participants oral exam (approx. 20 min) **Examination prerequisites:** M.Inf.2201.Ex: At least 50% of exercises solved **Examination requirements:** Knowledge of the principles, algorithms, and methods of probabilistic reasoning	6 C

Course: Probabilistic Machine Learning – Exercise (Exercise)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** B.Inf.1236 Machine Learning Basic knowledge of linear algebra, calculus, and probability
Language: English	**Person responsible for module:** Prof. Dr. Fabian Sinz Dr. Johannes Söding
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 50	

Additional notes and regulations: The course can be taken in parallel to B.Inf.1237 Deep Learning.

Georg-August-Universität Göttingen Module M.Inf.2241: Current Topics in Machine Learning	5 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students • have gained a deeper knowledge in specific topics within the field of machine learning • have improved their oral presentation skills • know how to methodically read and analyse scientific research papers • know how to write an analysis of a specific research field based on their analysis of state-of-the-art research • have improved their ability to work independently in a pre-defined context	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Current Topics in Machine Learning (Seminar)	2 WLH
Examination: Oral presentation (approx. 30 min.) and term paper (max. 5000 words) **Examination requirements:** Knowledge in a specific field of machine learning; ability to present the acquired knowledge in a both orally and in a written report.	5 C

Admission requirements: none	**Recommended previous knowledge:** B.Inf.1236 Machine Learning B.Inf.1237 Deep Learning (the seminar can accompany lecture in the same term)
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.2242: Journal Club Machine Learning and Computational Neuroscience**	5 C 2 WLH

Learning outcome, core skills: After successful completion of the module, students • have gained a deeper knowledge in specific topics within the fields of machine learning and computational neuroscience • have improved their oral presentation and discussion skills • know how to methodically read and critically analyse original scientific research papers • are able to lead a scientific discussion on an original research paper	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Journal Club Machine Learning and Computational Neuroscience	2 WLH
Examination: Oral Presentation (approx. 30 minutes), not graded **Examination prerequisites:** Regular participation **Examination requirements:** Knowledge of current topics in machine learning and computational neuroscience; ability to present the acquired knowledge orally and lead a discussion on the topic.	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 10	

Georg-August-Universität Göttingen **Module M.Inf.2501: Challenges and Perspectives in Neural Data Science**	3 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students have gained • an overview of recent fundamental research questions and future perspectives in systems and computational neuroscience • an understanding of the neuroscientific background and the data science problems addressed by the relevant research groups • the capabilities to make an informed choice about how to design their further curriculum and where and how to conduct their Master's project	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Challenges and Perspectives in Neural Data Science (Lecture) *Contents*: In each lecture, one research group at the Göttingen campus introduces their research questions, neuroscience background and data science methods used.	2 WLH
Examination: Term paper (max. 1000 words), not graded **Examination requirements:** Based on the content of the lecture series and their own additional research, students formulate a short pitch for a potential Master's thesis project in a neuroscience lab at the Göttingen Campus. The pitch describes the motivation and background of the project, the gap in knowledge, the approach and expected results, as well as the significance of the project. It should be based on at least one published research paper of the group of interest.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker Prof. Dr. Fabian Sinz
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 2
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.Inf.2541: Current Topics in Computational Neuroscience**	5 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students • have gained a deeper knowledge in specific topics within the field of computational neuroscience • have improved their oral presentation skills • know how to methodically read, critically analyse and discuss original scientific research papers • know how to write an analysis of a specific research field based on their analysis of state-of-the-art research • have improved their ability to work independently in a pre-defined context	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Current Topics in Computational Neuroscience (Seminar)	2 WLH
Examination: Oral presentation (approx. 30 min) and term paper (max. 5000 words) **Examination prerequisites:** Regular participation **Examination requirements:** Knowledge of a current topic in computational neuroscience; ability to present the acquired knowledge in a both orally and in a written report.	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.Inf.2801: Research Lab Rotation	12 C 1 WLH
Learning outcome, core skills: After successful completion of the module, students are able to plan and conduct a research project, and present its results in a written form; they acquire project management skills and learn to work collaboratively in a data science team.	**Workload:** Attendance time: 14 h Self-study time: 346 h
Course: Research Lab Rotation (Internship) *Contents*: Students perform a two-month research project in the area of data science in an academic research lab.	1 WLH
Examination: Written report (max. 3000 words) and presentation (approx. 20 min.), not graded **Examination requirements:** Written presentation of the background of the project and the methodology used, as well as a presentation and discussion of the results obtained. The report should be written in the style of a scientific paper and follow the format common in the field.	12 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Alle
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 3 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.Inf.2802: Industry internship**	12 C 1 WLH

Learning outcome, core skills: Students perform a two-month data science project in a company according to an internship plan to be agreed upon between the student, the teacher and the company.	**Workload:** Attendance time: 14 h Self-study time: 346 h

Course: Industry internship (Internship) *Contents*: Students perform a two-month data science project in a company.	1 WLH
Examination: Written report (max. 3000 words) and presentation (approx. 20 min.), not graded **Examination requirements:** Written presentation of the background of the project and the methodology used, as well as a presentation and discussion of the results obtained. The report should be written in the style of a scientific paper and follow the format common in the field.	12 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** Alle
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 3 - 4

Additional notes and regulations: The duration of the internship is 2-3 month.

Georg-August-Universität Göttingen Module M.Inf.2901: Master’s Thesis	30 C 1 WLH
Learning outcome, core skills: After successful completion of the module, students • know how to structure a research paper, • are familiar with formal and structural norms regarding outline, format, bibliography, etc., • understand the principles of good scientific writing, are able to apply them to their own writing and revise manuscripts of others accordingly. By writing the Master's thesis, students are enabled to work on a problem within a defined period of time using the methods of their subject area. Using this concrete problem, they work out the scientific context, select suitable research methods and carry out and evaluate corresponding investigations. On this basis, they arrive at scientifically justified statements.	**Workload:** Attendance time: 14 h Self-study time: 886 h
Course: Scientific Writing (Course)	1 WLH
Examination: Master's thesis **Examination prerequisites:** Students submit an outline for their thesis as well as drafts for abstract, introduction and related work sections, review drafts by peers and revise their drafts according to peer feedback. **Examination requirements:** By writing the Master's thesis, the student proves that he or she is able to work on a problem within the specified period of time using the methods of his or her subject area, to develop an independent, scientifically justified judgement, to arrive at scientifically sound statements and to present the results appropriately in terms of language and form.	30 C

Admission requirements: Modules of the degree programme totalling at least 48 C, including at least 24 C each from the subject study programme and the professionalisation area	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Alle Prof. Dr. Alexander Ecker
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 4

Georg-August-Universität Göttingen **Module M.Inf.356-1: Personalized Medicine**	3 C (incl. key comp.: 3 C) 2 WLH
Learning outcome, core skills: Die Studierenden kennen die Ziele, Methoden, Anwendungen und Entwicklungen einer personalisierten Medizin. Sie können diese in Bezug auf Anwendungsfelder der personalisierten Medizin in Forschung und Versorgung exemplarisch erläutern. Die Studierenden können die Bedeutung der interdisziplinären Arbeit auf dem Gebiet der personalisierten Medizin erläutern und bewerten.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Personalized Medicine (Course) *Contents*: Werden entsprechend der aktuellen Entwicklung dieses Fachgebietes regelmäßig angepasst. Ein regelmäßig überarbeitetes Literaturverzeichnis wird zu Beginn der Lehrveranstaltung ausgegeben.	2 WLH
Examination: Klausur (90 Minuten) oder mündl. Prüfung (ca. 20 Minuten) **Examination prerequisites:** Regelmäßige und aktive Teilnahme an der Lehrveranstaltung.	3 C
Examination requirements: Die Studierenden beschreiben die Ziele, Methoden, Anwendungen und Entwicklungen einer personalisierten Medizin. Sie können die interdisziplinäre Bedeutung des Themas darstellen und Anwendungsfelder der personalisierten Medizin in Forschung und Versorgung exemplarisch erläutern. Die Studierenden können die Potentiale des behandelten interdisziplinären Forschungsgebietes kritisch bewerten.	

Admission requirements: none	**Recommended previous knowledge:** Für Medizin-Informatiker wird der vorherige Besuch des Bachelor-Moduls B.Inf.1351: Grundlagen der Biomedizin empfohlen.
Language: German, English	**Person responsible for module:** UnivProf. Dr. rer. nat. Ulrich Sax Rienhoff, Otto, Prof. Dr. med.
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.MED.0001: Linear Models and their Mathematical Foundations**	9 C 6 WLH

Learning outcome, core skills: **Contents** Tests for multiple samples, multivariate normal distribution, distribution of quadratic forms, linear regression models, ANOVA models, ordinary and generalized least squares estimators, formulation of hypotheses, F-test, confidence intervals for model parameters, singular models, factorial designs, asymptotic methods **The students learn to** - master the fundamental methods for data analysis in case of multiple samples, - conduct an analysis of variance using statistical software, - interpret the results.	**Workload:** Attendance time: 84 h Self-study time: 186 h

Course: Lineare Modelle (Lecture)	4 WLH
Course: Lineare Modelle (Exercise)	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points **Examination requirements:** In the examination, the students show that for the given problem they can formulate an adequate linear model, estimate its parameters and test hypotheses using a statistical software package. Moreover, they can interpret the results and critically assess them. The examination consists (to the same extent) of both the Lectures and Exercises.	9 C

Admission requirements: none	**Recommended previous knowledge:** Mathematische Grundlagen der angewandten Statistik
Language: English	**Person responsible for module:** Prof. Dr. Tim Friede
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1
Maximum number of students: 30	

Additional notes and regulations: The actual examination type will be published at the beginning of the semester.

Georg-August-Universität Göttingen **Module M.MED.0003: Event Data Analysis**	6 C 4 WLH

Learning outcome, core skills: **Inhalt:** Kaplan-Meier estimator of survival functions, confidence intervals for Kaplan-Meier curves, hypothesis tests comparing survival curves, Cox proportional hazards model, parametric alternatives to the Cox proportional hazards model, counting processes, diagnostic methods for proportional hazards, frailty models, multivariate survival models, models for recurrent events **Qualifikationsziele:** The students • learn about the foundations and general principles of event data analysis • get familiar with standard and more advanced methods for event data analysis • learn how to implement these methods in statistical software using appropriate numerical procedures.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Ereigniszeitanalyse (Lecture)	2 WLH
Course: Ereigniszeitanalyse (Exercise)	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points **Examination requirements:** The students demonstrate their general understanding of statistical models and data analysis techniques for event data analysis. For a given problem they can critically assess the advantages and disadvantages of various models. Furthermore, they can fit an appropriate model using statistical software and interpret the results correctly for a given problem. The exam covers contents of both the lecture and the exercise class.	6 C

Admission requirements: keine	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Tim Friede
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 3
Maximum number of students: not limited	

Additional notes and regulations:

The actual examination type will be published at the beginning of the semester.

Georg-August-Universität Göttingen **Module M.MED.0004: Clinical Trials**	6 C 4 WLH

Learning outcome, core skills: **Inhalt:** Classification of clinical trials by purpose and development phase, clinical study protocol, randomization, treatment blinding, international guidelines on design, conduct and analysis of clinical trials, ethical issues in clinical trials, crossover trials, sample size calculation, internal pilot study design, group-sequential and adaptive designs, systematic reviews and meta-analyses of randomized controlled clinical trials. **Qualifikationsziele:** The students • learn about the foundations and general principles of design, conduct and analysis of clinical trials • get familiar with software to design clinical trials • learn how to carry out a meta-analysis using appropriate software.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Clinical Trials (Lecture)	2 WLH
Course: Clinical Trials (Exercise)	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points	6 C

Examination requirements: The students demonstrate their understanding of design, conduct and analysis of clinical trials. For a given problem they can critically assess the advantages and disadvantages of various study designs. They can plan a study using appropriate software. Furthermore, they can carry out a meta-analysis of randomized controlled trials, assess it for biases and heterogeneity, and interpret the results. The exam covers contents of both the lecture and the exercise class.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Tim Friede
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: not limited	

Additional notes and regulations: The actual examination type will be published at the beginning of the semester.

Georg-August-Universität Göttingen **Module M.MED.0006: Genetic Epidemiology**	6 C 4 WLH
Learning outcome, core skills: Studies in molecular / genetic epidemiology are investigating possible genetic components that are contributing to a disease or, more general, to a phenotype. The studies include population studies and family studies. The difference with classical epidemiology is mainly given by the incorporation of correlations of the genetic structures and of family members or close populations and by the highdimensionality oft many studies. The course will discuss the most important study types and statistical and epidemiological methods. The lecture will also give necessary introductions to genetics as well as epidemiology. The students learn about • the description of genetically co-determined phenotypes for diseases in populations and families • the discovery of risk faktors that are on one hand associated with the phenotype in the population or on the other hand provoke familial aggregations • the modelling of the role of genetic risk faktors for diseases on the population and family level • the prediction or risk calculation based on populations or families.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Genetic Epidemiology (Lecture)	2 WLH
Course: Genetic Epidemiology (Exercise)	2 WLH
Examination: 1st part examination: ca. 30 minutes oral presentation and written draft (max.10 pages) - contents: critics of the references of 1-2 scientific articles. 2nd part examination: oral examination (ca. 20 minutes) **Examination prerequisites:** Constant attandance of exercisess (80%). At least 50% of the earned points at regular homeworks. **Examination requirements:** 1. part examination: In the talk together with the write-up they demonstrate that they can apply their knowledge and understanding in the context of a literature by demonstrating an understanding of the study goals, the recruitment, the study design, the materials, the methods and the results. For all this an understanding of why investigators took certain choices and why certain aspects are good or bad are expected in the critique. In particular it is also expected that basic principle of the methods will be understand and looked up even if they are extensions of the direct material covered in class. 2nd part exmination: The students demonstrate their general understanding of genetic and statistical models and designs. They know about the advantages and disadvantages of the different research questions and designs. They know the general properties of the statistical approaches and can critically assess the appropriateness for specific problems and	6 C

apply them. The exam covers contents of both the lecture and the exercise class.	

Examination requirements: The students demonstrate their general understanding of genetic and statistical models and designs. They know about the advantages and disadvantages of the different research questions and designs. They know the general properties of the statistical approaches and can critically assess the appropriateness for specific problems and apply them. The exam covers contents of both the lecture and the exercise class.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Heike Bickeböller
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.MED.0011: Nonparametric procedures**	6 C 4 WLH
Learning outcome, core skills: Part 1: Ranking procedures (tests, confidence intervals, sample size planning) for two and several samples as well as factorial designs involving independent observations. Part 2: Ranking procedures for repeated measures and clustered data, in particular analysis of time curves. All procedures are valid for continuous and discrete metric data as well as ordered categorical data and the common "correction for ties" formulas are shown to be outdated. All procedures are motivated by real data examples which are analyzed in the exercises using different R-packages. To enhance the understanding of the ideas and procedures simple derivations will be presented in the lectures and worked out in the exercises. Several (unfortunately) common misunderstandings of using and interpretation of ranking procedures are discussed, this includes the following misunderstandings: heuristic idea of the rank transform technique, ranking procedures only valid for continuous data, use of rankings in case of skewed distributions, use of rankings for testing the equality of medians.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Nichtparametrische Verfahren (Lecture) **Literatur / Unterlagen:** Manuscript of a forthcoming book going to appear in the Springer-Series: Lecture Notes in Statistics or electronic version of this book via SUB, if already printed at the beginning of the semester. Review paper and lecture notes of previous lectures on ranking methods for paired samples and repeated measures procedures.	2 WLH
Course: Nichtparametrische Verfahren (Exercise)	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points **Examination requirements:** Understanding of the general models, ideas and interpretation of ranking procedures, application of these procedures to practical data set / examples, appropriate use of statistical software for the analysis of examples and correct interpretation of the results. The exam covers contents both of the lectures and the exercises.	6 C

Admission requirements: keine	**Recommended previous knowledge:** Linear Models and their Mathematical Foundations
Language: German, English	**Person responsible for module:** Prof. Dr. rer. nat. Edgar Brunner
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**

twice	2 - 3
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module M.MED.0020: Analysis of Longitudinal and Time-to-Event Data	6 C 4 WLH

Learning outcome, core skills: **Description** Both longitudinal and time-to-event data frequently arise when observational units such as individuals are followed over a period of time. Longitudinally measured responses, also called repeated measures data, are correlated within subjects and thus require special statistical techniques for valid analysis and inference. Time-to-event data arise when interest is focused on the time elapsing until an event such as onset of infection or death is experienced. Such events may be subject to scientific interest where one tries to understand their cause or establish risk factors. The analysis of time-to- event data is complicated by the issue of censoring, a condition in which the time to the occurrence of the event is only partially known. Occasionally, in a longitudinal study, information on both repeated measurements and the time at which an event of particular interest occurs is collected in the same sample. The purpose of this course is to provide a gentle, yet intense, introduction of the most commonly used statistical methods for analyzing longitudinal and time-to-event data, both separately and jointly. The lectures will be accompanied by tutorials covering both theoretical aspects and the practice of solving applied exercises using the software package R. **Contents** Part I - Analysis of Longitudinal Data • Generalized linear mixed-effects modelling • Generalized estimating equations approach • Latent growth curve modelling Part II - Analysis of Time-to-Event Data • Nonparametric estimation and comparison of functions of failure time • Parametric and semiparametric regression modelling • Competing risks and multistate models • Random effects models for related observations Part III - Joint Modelling of Longitudinal and Time-to-Event Data **Learning objectives** By the end of the course, with reasonable effort, the students will be able to • explain key methodological approaches for the analysis of both repeated measures and time-to-event data, • perform appropriate statistical analyses of the resultant repeated measures and/or time-to-event data arising from a longitudinal study, • apply the methods that have been taught to data from a longitudinal study using the software R and interpret the results of such an analysis, • provide methodological guidance with respect to the planning and conduct of a new longitudinal study.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Analysis of Longitudinal and Time-to-Event Data (Lecture)	2 WLH
Course: Analysis of Longitudinal and Time-to-Event Data (Tutorial)	2 WLH
Examination: Written exam (90 min.) or Oral exam. (approx. 20 min.) **Examination prerequisites:** At least 50% of the possible points on the exercise sheets	6 C

Admission requirements: none	**Recommended previous knowledge:** Linear models and their mathematical foundations
Language: English	**Person responsible for module:** PD Dr. Steffen Unkel
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 3 - 4
Maximum number of students: 30	

Additional notes and regulations: The actual examination type will be published at the beginning of the semester.

Georg-August-Universität Göttingen **Module M.MED.0021: Experimental Design and Causal Inference**	6 C 4 WLH

Learning outcome, core skills:
• Sources of bias and the role of validation
• Design of experiments
  ◦ Randomization, stratification, blocking, blinding
  ◦ Optimal designs (with different optimality criteria)
• Inference for observational studies
  ◦ Directed acyclic graphs (DAGs)
  ◦ G-estimation
  ◦ Propensity score methods
• Application of causal inference methods introduced for observational studies to randomized controlled trials to adjust for post-randomization selection
Learning objectives
By the end of the course, with reasonable effort, the students will be able to
• explain key principles of design of experiments and causal inference
• design and analyze experiments avoiding common mistakes which can lead to systematic bias
• apply causal inference techniques taught using the software R and interpret the results
	Workload:
	Attendance time:
	56 h
	Self-study time:
	124 h

Course: Experimental Design and Causal Inference (Exercise)	2 WLH
Course: Experimental Design and Causal Inference (Lecture)	2 WLH
Examination: Written exam. (90 min.) or Oral exam (approx. 20 min.) **Examination prerequisites:** Achievement of at least 50% of the exercise points **Examination requirements:** In the examination, the students show that they understand the basic principles of experimental designs as well as the problems associated with violating these principles. They know methods from causal inference to correct for bias in observational data. Moreover, they are able to critically assess the assumptions of these methods and interpret the results. The examination consists (to the same extent) of both the Lectures and Exercises.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Tim Friede Prof. Dr. Sarah Friedrich
Course frequency: once a year	**Duration:** 1 semester[s]

Number of repeat examinations permitted:	Recommended semester:
three times	Master: 1 - 4
Maximum number of students: 30	

Additional notes and regulations:
The actual examination type will be published at the beginning of the semester.

Georg-August-Universität Göttingen **Module M.Mat.0731: Advanced practical course in scientific computing**	10 C 4 WLH

Learning outcome, core skills: **Learning outcome:** After having successfully completed the module, students are familiar with the analysis of problems in the area "Scientific computing" arising in practice. They • develop large programming projects doing individual or group work; • analyse complex data sets and process them; • use special numerical libraries; • are experienced with advanced methods for the numerical solution of applied problems; • are familiar with basic principles of modular and structured programming in the context of scientific computing. **Core skills:** After having successfully completed the module, students possess advanced practical experience in the area "Scientific computing". They will be able to • identify mathematical problems in applied problems and convert them into a mathematical model; • implement numerical algorithms in a programming language or a user system; • structure complex programming tasks such that they can be efficiently done by group work.	**Workload:** Attendance time: 56 h Self-study time: 244 h

Course: Advanced practical course in scientific computing (Internship)	4 WLH
Examination: Term Papermax. 50 pages (not counted appendices), alternatively, presentation (appr. 30 minutes) **Examination prerequisites:** Regular participation in the practical course	10 C

Examination requirements: • analysis and systematisation of applied problems; • knowledge in special methods of optimisation; • good programming skills.	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.2300 Proficiency in object oriented programming
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: winter or summer semester, on demand	**Duration:** 1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**

twice	Master: 1 - 3
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Institute of Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.0741: Advanced practical course in stochastics**	10 C 6 WLH

Learning outcome, core skills: **Learning outcome:** After having successfully completed the module, students have deepened and expanded their knowledge of a stochastical simulation and analysis software that they acquired in the module "Practical course in stochastics". They have acquired advanced knowledge in project work in stochastics. They • autonomously implement and interpret more complex stochastical problems using suitable software; • autonomously write more complex programs using suitable software; • master some advanced methods of statistical data analysis and stochastical simulation like e. g. kernel density estimation, the Bootstrap method, the creation of random numbers, the EM algorithm, survival analysis, the maximum-penalized-likelihood estimation and different test methods. **Core skills:** After having successfully completed the module, students will be able to • handle practical problems with the aid of advanced stochastical methods and the suitable stochastical simulation and analysis software and present the obtained results well; • use advanced visualisation methods for statistical data (e. g. of spatial data); • apply different algorithms to the suitable stochastical problem.	**Workload:** Attendance time: 84 h Self-study time: 216 h

Course: Advanced practical course in stochastics (Internship)	6 WLH
Examination: Presentation (appr. 30 minutes) and term paper (max. 50 pages not counted appendices) **Examination prerequisites:** Regular participation in the practical course	10 C

Examination requirements: Special knowledge in stochastics, especially mastery of complex stochastical simulation and analysis software as well as methods for data analysis	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.3140
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 3

Maximum number of students: not limited	

Additional notes and regulations:
Instructor: Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Phy.5601: Seminar Computational Neuroscience/Neuroinformatics**	4 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students ... • have deepened their knowledge of computational neuroscience / neuroinformatics by an independent elaboration of a topic; • have learned methods of presentation of topics from computer science; • are able to deal with (English-language) literature; • are able to present an informatic topic; • are able to lead a scientific discussion.	**Workload:** Attendance time: 28 h Self-study time: 92 h
Course: Seminar (Seminar) *Course frequency:* each semester	
Examination: Presentation (approx. 45 Min.) with written report (max. 7 S.) **Examination prerequisites:** regular participation **Examination requirements:** Independent preparation and presentation of research-related topics from the area of computational neuroscience / neuroinformatics as well as biophysics of neuronal systems.	4 C

Admission requirements: none	**Recommended previous knowledge:** B.Phy.5614
Language: English	**Person responsible for module:** Prof. Dr. Florentin Andreas Wörgötter
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 3
Maximum number of students: 14	

Georg-August-Universität Göttingen **Module M.Psy.1003: Affective Neurosciences**	6 C 4 WLH
Learning outcome, core skills: Students will acquire in-depth knowledge of current theories and neuroscientific findings from different areas of emotion and motivation research and learn the basics of psychophysiological methods (EEG, EMG, peripheral physiology, imaging techniques, eye movement measurement and pupillometry) and their application in these research fields. Academic achievement: Regular literature study, regular preparation of short presentations, active participation in discussion.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Affective Neurosciences 1 (Seminar)	
Course: Affective Neurosciences 2 (Seminar)	
Examination: Oral examination (approx. 20 minutes)	6 C
Examination requirements: Students will acquire an overview of central theories and neuroscientific findings in emotion and motivation research. These will be discussed in the examination.	

Admission requirements: keine	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Annekathrin Schacht
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module M.Psy.901: From Vision to Action**	6 C 4 WLH

Learning outcome, core skills: Communication of scientific research approaches as well as the scientific knowledge about the visual system in primates (human and non-human primates) and visuomotor integration at an advanced level. Academi achievement: Regular study of literature, preparation and presentation of at least one short paper in the seminar and regular active participation in the discussion in the seminar and in the lecture.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Biological Psychology – Neurosciences 1 (Lecture)	2 WLH
Course: Biological Psychology – Neurosciences 2 (Seminar)	2 WLH
Examination: Written examination (60 minutes)	6 C

Examination requirements: Comprehensive knowledge of the lecture contents. Theoretical knowledge and the ability apply it and to make cross-connections are tested.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Gail
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1
Maximum number of students: 25	

Additional notes and regulations: Max. number of participants: Lecture: not limited Seminar: 30 participants

Georg-August-Universität Göttingen Module M.WIWI-QMW.0001: Generalized Regression	6 C 4 WLH
Learning outcome, core skills: The students • gain an overview on extended regression modelling techniques that allow to analyse data with non-normal responses. • learn about approaches for modeling nonlinear effects in scatterplot smoothing. • get an introduction to additive models and mixed models for complex regression analyses. • learn how to implement these approaches using statistical software packages.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Generalized Regression (Lecture) *Contents*: Generalized linear models (binary and Poisson regression, exponential families, maximum likelihood estimation, iteratively weighted least squares regression, tests of hypotheses, confidence intervals, model selection and model checking, categorical regression models), nonparametric smoothing techniques (penalized spline smoothing, local smoothing approaches, general properties of scatterplot smoothers, choosing the smoothing parameter, bivariate and spatial smoothing, generalized additive models), mixed models, quantile regression Literatur: Fahrmeir, Kneib, Lang, Marx (2013): Regression - Models, Methods and Applications, Springer.	2 WLH
Course: Generalized Regression (Tutorial) *Contents*: Generalized linear models (binary and Poisson regression, exponential families, maximum likelihood estimation, iteratively weighted least squares regression, tests of hypotheses, confidence intervals, model selection and model checking, categorical regression models), nonparametric smoothing techniques (penalized spline smoothing, local smoothing approaches, general properties of scatterplot smoothers, choosing the smoothing parameter, bivariate and spatial smoothing, generalized additive models), mixed models, quantile regression	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes)	6 C
Examination requirements: In the exam, the students demonstrate their ability to choose, fit and interpret extended regression modeling techniques. They show a general understanding of the derived estimates and their interpretation in various contexts. The students are able to implement complex regression models using statistical software and to interpret the corresponding results. The exam covers contents of both the lecture and the exercise class.	

Admission requirements:	**Recommended previous knowledge:**

none	Module B.WIWI-QMW.0001: Linear Models
Language: English	**Person responsible for module:** Prof. Dr. Thomas Kneib
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2
Maximum number of students: not limited	

Additional notes and regulations: The actual examination will be published at the beginning of the semester.

Georg-August-Universität Göttingen **Module M.WIWI-QMW.0002: Advanced Statistical Inference (Likelihood & Bayes)**	6 C 4 WLH

Learning outcome, core skills: Upon completion of the module, the students have acquired the following competencies: • foundations and general properties of likelihood-based inference in statistics, • bayesian approaches to statistical learning and their properties, • implementation of both approaches in statistical software using appropriate numerical procedures.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Advanced Statistical Inference (Likelihood & Baye) (Lecture) *Contents*: The likelihood function and likelihood principles, maximum likelihood estimates and their properties, likelihood-based tests and confidence intervals (derived from Wald, score, and likelihood ratio statistics), expectation maximization algorithm, Bootstrap procedures (estimates for the standard deviation, the bias and confidence intervals), Bayes theorem, Bayes estimates, Bayesian credible intervals, prior choices, computational approaches for Bayesian inference, model choice, predictions Literatur: Held, Sabanes Bové (2014): Applied Statistical Inference, Springer	2 WLH
Course: Advanced Statistical Inference (Likelihood & Bayes) (Exercise) *Contents*: The likelihood function and likelihood principles, maximum likelihood estimates and their properties, likelihood-based tests and confidence intervals (derived from Wald, score, and likelihood ratio statistics), expectation maximization algorithm, Bootstrap procedures (estimates for the standard deviation, the bias and confidence intervals), Bayes theorem, Bayes estimates, Bayesian credible intervals, prior choices, computational approaches for Bayesian inference, model choice, predictions	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes)	6 C

Examination requirements: The students demonstrate their general understanding of likelihood-based and Bayesian inference for different types of applications and research questions. They know about the advantages and disadvantages as well as general properties of both approaches, can critically assess the appropriateness for specific problems, and can implement them in statistical software. The exam covers contents of both the lecture and the exercise class.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Thomas Kneib

Course frequency: every year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 2
Maximum number of students: not limited	

Additional notes and regulations: The actual examination will be published at the beginning of the semester.

Georg-August-Universität Göttingen Module M.WIWI-QMW.0009: Introduction to Time Series Analysis	6 C 4 WLH

Learning outcome, core skills: The students: • learn concepts and techniques related to the analysis of time series and forecasting, • gain a solid understanding of the stochastic mechanisms underlying time series data, • learn how to analyse time series using statistical software packages and how to interpret the results obtained.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Introduction to Time Series Analysis (Lecture) *Contents*: Classical time series decomposition analysis (moving averages, transformations of time series, parametric trend estimates, seasonal and cyclic components), exponential smoothing, stochastic models for time series (multivariate normal distribution, autocovariance and autocorrelation function), stationarity,spectral analysis, general linear time series models and their properties, ARMA models, ARIMA models, ARCH and GARCH models. **Literature** Kreiß & Neuhaus (2006): Einführung in die Zeitreihenanalyse, Springer. Rinne & Specht (2002): Zeitreihen - Statistische Modellierung, Schätzung und Prognose, Vahlen. Chat¿eld (2003): The Analysis of Time Series: An Introduction, Chapman & Hall / CRC Shumway & Sto¿er (2006): Time Series Analysis and its Applications, Springer Schlittgen & Streitberg (2001): Zeitreihenanalyse, Oldenbourg. Lütkepohl & Krätzig (2010): Applied Time Series Econometrics (Themes in Modern Econometrics), Cambridge University Press.	2 WLH
Course: Introduction to Time Series Analysis (Tutorial) *Contents*: Practical and theoretical exercises covering the content of the lecture. Implementation of time series models and estimation by common statistical software (e.g. R or Matlab). Interpretation of estimation results.	2 WLH
Examination: Written examination (90 minutes)	6 C

Examination requirements: The students show their ability to analyze time series using specific statistical techniques, can derive and interpret properties of stochastic models for time series, and can decide on appropriate models for given time series data. The students are able to implement time series analyses using statistical software and to interpret the corresponding results. The exam covers contents of both the lecture and the exercise class.	

Admission requirements: none	**Recommended previous knowledge:** B.WIWI-OPH.0006 Statistics and M.WIWI-QMW.0004 Econometrics I
Language: English	**Person responsible for module:** Prof. Dr. Helmut Herwartz
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 3
Maximum number of students: 50	

Georg-August-Universität Göttingen **Module M.WIWI-QMW.0010: Multivariate Statistics**	6 C 4 WLH
Learning outcome, core skills: The students: • learn the basic concepts of multivariate data analysis, • know how to apply the most common methods of multivariate statistics in practice, • learn how to implement multivariate statistical approaches using the software package R, • know how to interpret the results of multivariate data analyse.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Multivariate Statistics (Lecture) *Contents*: Multivariate distributions and their properties, multivariate normal distribution, principal component analysis, factor analysis, discriminant analysis, cluster analysis **Literatur:** Everitt, B. S. and Hothorn, T. (2011): An Introduction to Applied Multivariate Analysis with R, Springer.	2 WLH
Course: Multivariate Statistics (Exercise) *Contents*: Multivariate distributions and their properties, multivariate normal distribution, principal component analysis, factor analysis, discriminant analysis, cluster analysis	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes) **Examination prerequisites:** Exercises (50% successful completion)	6 C
Examination requirements: In the exam, the students demonstrate that they are able to apply the basic concepts of multivariate statistics. They can decide for a suitable procedure given an applied problem, implement the approach in statistical software and interpret the results. The exam consists of material from both the lecture and the exercise class.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Thomas Kneib
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 3
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module M.WIWI-QMW.0012: Multivariate Time Series Analysis	6 C 4 WLH

Learning outcome, core skills: The students: • learn concepts and techniques related to the analysis of multivariate time series and the forecasting thereof. • learn to characterize the dynamic interrelationship between the variables of dynamic systems, • learn to relate economic models with restrictions implied by its empirical counterpart, • learn how to analyse multivariate time series using by means of statistical software packages and to interpret the results obtained.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Multivariate Time Series Analysis (Lecture) *Contents*: Vector Autoregressive and Vector Moving Average representations Model selection and estimation, Unit roots in vector processes, Vector autoregressive vs. vector error correction modeling, structural vectorautoregressions, Impulse response analysis, forecasting, forecast error variance decomposition **Literature** Lütkepohl, H. (2007): The new Introduction to Multiple Time Series Analysis, Springer, New-York. Lütkepohl, H., Krätzig, M. (2004): Applied Time Series Econometrics, Chapter 2, 3 and 4, Cambridge University Press, Cambridge. Hamilton, J.D. (1994): Time Series Analysis, Princeton University Press, Princeton, New Jersey.	2 WLH
Course: Multivariate Time Series Analysis (Tutorial) *Contents*: Practical and theoretical exercises covering the content of the lecture. Implementation of multivariate time series models and estimation in common statistical software (e.g. R or Matlab). Interpretation of estimation results.	2 WLH
Examination: Written examination (90 minutes)	6 C

Examination requirements: The students show their ability to analyze systems of time series using specific statistical techniques, can derive and interpret properties of stochastic models for time series, and can decide on appropriate models for given data. The students are able to implement time series analyses using statistical software and to interpret the corresponding results. The exam covers contents of both the lecture and the exercises.	

Admission requirements: none	**Recommended previous knowledge:** B.WIWI-OPH.0006 Statistics, M.WIWI-QMW.0004 Econometrics I,

	M.WIWI-QMW.0009 Introduction to Time Series Analysis
Language: English	**Person responsible for module:** Prof. Dr. Helmut Herwartz
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 4

Georg-August-Universität Göttingen **Module M.WIWI-QMW.0016: Spatial Statistics**	6 C 4 WLH
Learning outcome, core skills: The students • get familiar with basic concepts and examples of stochastic processes. • learn about the principle possibilities to include spatial information in statistical models. • acquire experience in the practical analysis of spatial data • learn how to interpret the results of spatial analyses	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Spatial Statistics (Lecture) *Contents*: Stochastic processes in discrete and continuous time, Wiener process, Poisson process, Markov chains, statistical analysis of spatially oriented data, spatial models for point-referenced data (geostatistics, kriging), spatial models for regional data (Markov random fields), spatial point processes, spatial stochastic processes, statistical inference in spatial statistics. **Literatur:** Diggle, Ribeiro (2007): Model-based Geostatistics, Springer. Rue, Held (2005): Gaussian Markov Random Fields, Chapman & Hall / CRC. Møller & Waagepetersen (2003): Statistical inference and simulation for spatial point processes, Chapman & Hall/CRC.	2 WLH
Course: Spatial Statistics (Exercise) *Contents*: Stochastic processes in discrete and continuous time, Wiener process, Poisson process, Markov chains, statistical analysis of spatially oriented data, spatial models for point-referenced data (geostatistics, kriging), spatial models for regional data (Markov random fields), spatial point processes, spatial stochastic processes, statistical inference in spatial statistics.	2 WLH
Examination: Written examination (90 minutes) or oral examination (ca. 20 minutes)	6 C
Examination requirements: The students show in the exam that they have learned to perform the basic steps and calculations involved in analyses of stochastic processes and spatial data. They can choose the most appropriate model for a given problem and can implement this model in statistical software. In addition, the resulting estimates can be interpreted and the results can be critically evaluated. The exam covers contents of both the lecture and the exercise class.	

Admission requirements: none	**Recommended previous knowledge:** none
Language:	**Person responsible for module:**

English	Prof. Dr. Elisabeth Bergherr
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 3
Maximum number of students: not limited	

Additional notes and regulations:
The actual examination will be published at the beginning of the semester.

Georg-August-Universität Göttingen Module M.WIWI-QMW.0033: Current Topics in Applied Statistics	6 C 2 WLH
Learning outcome, core skills: The students: • learn how to study current topics in applied statistics independently and how to make themselves familiar with the state of the art of current research, • learn how to present the current state of the art in a presentation in a way that makes the contents accessible to a wider audience (and in particular other students), • can evaluate current publication with respect to their applicability for a given research question, • can implement novel statistical methods and apply them to empirical data.	**Workload:** Attendance time: 28 h Self-study time: 152 h
Course: Current Topics in Applied Statistics (Seminar) *Contents*: In the seminar, current topics in applied statistics will be presented and discussed by the students.	2 WLH
Examination: Term paper (max. 15 pages) with presentation (ca. 45 minutes) **Examination prerequisites:** Regular attendance.	6 C
Examination requirements: The students demonstrate their ability to present statistical and econometric models and results and to document their findings in a corresponding report.	

Admission requirements: none	**Recommended previous knowledge:** M.WIWI-QMW.0002 Advanced Statistical Inference (Likelihood & Bayes), M.MED.0001 Lineare Modelle und ihre mathematischen Grundlagen, M.WIWI-QMW.0021 Introduction to R
Language: English	**Person responsible for module:** Prof. Dr. Thomas Kneib
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 4
Maximum number of students: 15	

Additional notes and regulations:
The module is suitable for students of the Master's degree program Applied Statistics, as advanced statistical knowledge is required.

Georg-August-Universität Göttingen **Module M.WIWI-QMW.0035: Statistical and Deep Learning**	6 C 4 WLH

Learning outcome, core skills: After completing the module, the students are familiar with the current state of research in modern statistical and deep learning algorithms and their practical application. They know the theoretical foundations and the technical implementation of the methods. Students can apply the methods to real data sets and assess the advantages and disadvantages of different methods.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Statistical and Deep Learning (Seminar) *Contents*: Introduction to neural networks, minimization algorithms (e.g. Stochastic Gradient Descent), Deep Neural Nets (e.g. Convolutional Neural Nets, Recurrent Neural Nets), application of deep learning algorithms to different objectives (e.g. image recognition, voice recognition, Long-Term Short-Term financial time series), current procedures of Natural Language Processing and Machine Learning techniques (e.g. Random Forests, Support Vector Machines).	4 WLH
Examination: (max. 15 pages) and presentation (approx. 30 minutes)	6 C

Examination requirements: The students demonstrate a basic understanding of deep learning methods. They demonstrate the successful reception of the scientific literature on a specific topic as well as the ability to present their own subject matter in an understandable manner to a foreign audience.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Dr. Benjamin Säfken, Dr. Alexander Silbersdorff
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 20	

Georg-August-Universität Göttingen Module SK.Bio-NF.7001: Neurobiology	3 C 2 WLH
Learning outcome, core skills: The students should acquire comprehension in form and function of neurons and their anatomical and physiological features (genetics, subcellular organization, resting membrane potential, action potential generation, stimulus conduction, transmitter release, ion channels, receptors, second messenger cascades, axonal transport). The students acquire knowledge of the physiological basics of sensory systems (olfactory, gustatory, acoustic, mechanosensory and visual perception) as well as motor control. Based on this the students educe understanding for the relation between neuronal circuits and simple modes of behavior (central pattern generators, reflexes, and taxis movements). The students should conceptually learn how neuronal connections are modified by experience (cellular mechanisms of learning and memory) and should learn different types of modification of behavior based on experience and neuronal substrates. The students should acquire fundamental insight into the organization and function of brains and autonomous nervous systems of mammals and invertebrates. The neurobiological basis of behavioral control (orientation, communication, circadian rhythm and sleep as well as motivation and metabolism) is explained. The students will learn physiological and cellular mechanisms of aging and of neurodegenerative diseases.	**Workload:** Attendance time: 30 h Self-study time: 60 h
Course: Neurobiology (Lecture)	2 WLH
Examination: Written examination (90 minutes)	3 C
Examination requirements: The students should have the ability to assess coherence and facts of statements from the field of neurobiology; they should be able to answer questions on the structure and function of neurons and neuronal circuits. Furthermore they should be able to describe and compare neuronal basics of behavioral control, their experience-dependent modification and conceptual mechanisms of complex behavior; they should be able to describe and compare physiological mechanisms of sensory perception and different sensory modalities; they should be able to describe physiological and cellular mechanisms of aging and of neurodegenerative diseases.	

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge in Biology
Language: English	**Person responsible for module:** Prof. Dr. Andre Fiala
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4 - 6
Maximum number of students: 30	

Additional notes and regulations: The combination of this module with module SK.Bio.7001 is not possible.

Georg-August-Universität Göttingen **Module SK.Bio.357: Biological psychology III**	3 C 2 WLH
Learning outcome, core skills: The students acquire knowledge of advanced principles and concepts of neuroscientific biopsychology in the fields of the development of the nervous system, neuroplasticity, pain, multisensory integration, sensomotorics, sensory information processing, decision making, executive functions, attention, psychopharmacology, psychopathology.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Biologische Psychologie III (Lecture)	2 WLH
Examination: Written examination (60 minutes) **Examination requirements:** The students prove that they have achieved the above-mentioned learning objectives.	3 C

Admission requirements: none	**Recommended previous knowledge:** SK.Bio.355, SK.Bio.356
Language: German	**Person responsible for module:** Prof. Dr. Alexander Gail
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 5
Maximum number of students: 20	