Georg-August-Universität
Göttingen

Directory of Modules

zu der Prüfungs- und Studienordnung für den konsekutiven Master-Studiengang "Angewandte Data Science" (Amtliche Mitteilungen I 22/2023 S. 635)

Index by areas of study

I. Master’s Degree 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.

Provided that students have prior knowledge which largely corresponds to modules according to letters a) to d), corresponding modules with a total maximum of 49 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.

a. Fundamentals of Data Science

The following five modules of 32 C in total have to be successfully completed.

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 at least 5 C has to be successfully completed:

d. Machine Learning Methods

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 VII: “Computational Neuroscience”, “Bioinformatics”, "Medical Data Science", "Digital Humanities", "Computational Sustainability", "Digital Business Administration".

c. Key Competencies (12 C)

A total of at least 12 C have to be successfully completed according to the following regulations.

aa. Profession-specific Key Competencies

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

bb. Interdisciplinary Key Competencies

Modules amounting to a maximum of 6 C can be taken 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). The examination board decides on further selectable modules, which are to be announced in an appropriate manner.

d. Prior Knowledge in the Area of Professionalisation

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 of Computational Neuroscience

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

2. Elective Area "Computational Neuroscience"

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.
Only one of the modules M.Bio.310 and M.Bio.340 can be taken.

1. Biological Fundamentals

At least one module of a total of at least 8 C has to be successfully completed:

2. Elective Area "Bioinformatics"

A total of at least 10 C have to be successfully completed:

3. Optional Modules

Additionally, the following modules can be chosen:

IV. Application Domain "Medical Data Science"

A total of at least 18 C have to be successfully completed according to the following regulations. Only one of the modules M.Bio.310 and M.Bio.340 can be taken.

1. Fundamentals of Medical Data Science

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

2. Elective Area "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 the following regulations.

1. Fundamentals of Digital Humanities

The modules B.Inf.1904 and B.DH.02 are recommended if the competencies have not already been acquired.

2. Elective Area "Digital Humanities"

Additionally, the following modules can be chosen:

VI. Application Domain "Computational Sustainability"

A total of at least 18 C have to be successfully completed:

VII. Application Domain "Digital Business Administration"

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

1. Fundamentals of Business Administration

If students have no prior knowledge in Business Administration or Business Informatics, two of the following modules of a total of 12 C have to be successfully completed:

2. Elective Area "Digital Business Administration"

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

VIII. Connector Courses

IX. 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.105: Lecture series biology I - part A**	5 C 4 WLH

Learning outcome, core skills: The students acquire basic knowledge in different fields of Biology to assure a common basic level of knowledge for constitutive modules. The students learn basics in general biology (in particular evolution and phylogenetics), systematics of animals (overview of zoological biodiversity) and animal physiology (incl. physiological methods).	**Workload:** Attendance time: 56 h Self-study time: 94 h

Course: Biologische Ringvorlesung	4 WLH
Examination: Written examination (90 minutes) **Examination requirements:** The students should be able to verify statements on facts and connections from the fields of general biology, animal systematics and animal physiology. They should be able to answer questions on definition, function and relevance of evolutional, phylogenetic and animal physiological processes and methods in note form as well as to describe and compare these processes and methods. The written exam is conducted as an e-exam.	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Martin Göpfert
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 1
Maximum number of students: 240	

Georg-August-Universität Göttingen **Module B.Bio.106: Lecture series biology I - part B**	5 C 4 WLH

Learning outcome, core skills: The students acquire basic knowledge in different fields of biology (chemistry of life, cell biology, anthropology, ecology, behavior). After passing the module the students have the ability to understand location, structure and function of organizational layers of living organisms as well as the basics of interorganismic dependencies and functions in the interaction with the environment in an evolutionary context.	**Workload:** Attendance time: 56 h Self-study time: 94 h

Course: Biologische Ringvorlesung	4 WLH
Examination: Written examination (90 minutes) **Examination requirements:** The students should be able to verify statements on facts and connections from the fields of chemistry of life, cell biology, anthropology, ecology and behavior. They should be able to answer questions on definition, function and relevance of molecular, cell biological, organismic and ecological structures and processes in note form as well as to describe and compare these structures and processes. The written exam is conducted as an e-exam.	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Volker Lipka
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** 1
Maximum number of students: 240	

Georg-August-Universität Göttingen **Module B.DH.02: Introduction to Computational Image and Artefact Analysis**	6 C 4 WLH

Learning outcome, core skills: Die Studierenden • haben einen Überblick über wesentliche Gegenstände und Problemstellungen der Digitalen Bild- und Objektwissenschaft; • können wissenschaftliche, gesellschaftliche und ethische Folgen und Perspektiven der Digitalen Bild- und Objektanalyse einschätzen; • kennen zentrale Fragen der Digitalen Bild- und Objektwissenschaft, relevante Case Studies und die wichtigsten Werkzeuge zum Erstellen, Verwalten und Verarbeiten digitaler Daten (z.B. Korpusbildung, Bildverarbeitung, 3D Erfassung, Bild- und Objektdatenbanken, quantifizierende Methoden, Virtual Heritage).	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Einführung in die Digitale Bild- und Objektwissenschaft (Lecture)	2 WLH
Examination: Written examination (90 minutes) **Examination prerequisites:** regelmäßige Teilnahme am Tutorium sowie Ausarbeitung einer praktischen Anwendung im Umfang von max. 5 Seiten. **Examination requirements:** Die Studierenden weisen im Bereich der Bild- und Objektwissenschaften Kenntnisse spezifisch geisteswissenschaftlicher Fragestellungen, Vorgehensweisen und Forschungsergebnisse auf Grundlage digitaler Datenverarbeitung nach sowie die Fähigkeit, Methoden und Theoriebildungen in den Digital Humanities nachzuvollziehen und in Ansätzen zu reflektieren.	6 C

Course: Tutorium (Tutorial)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: German, English	**Person responsible for module:** Prof. Dr. Martin Gustav Langner
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 2
Maximum number of students: 25	

Georg-August-Universität Göttingen **Module B.Inf.1213: Quantum computing**	5 C 3 WLH
Learning outcome, core skills: 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.	**Workload:** 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 summer 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 and N-1 attempts presented to tutors **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) *Contents*: Students present their solutions of the homework exercises to tutors and discuss them with their tutors.	2 WLH

Admission requirements: none	**Recommended previous knowledge:** Knowledge of basic linear algebra and probability English language proficiency at level B2 (CEFR)
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 for Computer Vision	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 networks and other modern deep learning architectures • learn techniques for optimization and regularization of deep neural networks • learn applications of deep neural networks for computer vision tasks such as segmentation and object detection	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Deep Learning for Computer Vision (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 and N-1 attempts presented to tutors **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 for Computer Vision - Exercise (Exercise) *Contents*: Students present their solutions of the homework exercises to tutors and discuss them with their tutors.	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. Constantin Pape 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**	6 C 4 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: 56 h Self-study time: 124 h

Course: Visualization (Lecture, Exercise)	4 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.	6 C

Admission requirements: none	**Recommended previous knowledge:** Foundations of linear algebra and analysis (e.g. B.Mat.0801 and B.Mat.0802) and programming skills (e.g. B.Inf.1842).
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:** Foundations of linear algebra and analysis (e.g. B.Mat.0801 and B.Mat.0802) and programming skills (e.g. B.Inf.1842).
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-Silviu 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.1244: Data Management for Data Science	5 C 4 WLH

Learning outcome, core skills:	**Workload:**
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.	Attendance time: 56 h Self-study time: 94 h

Course: Data Management for Data Science (Lecture, Exercise)	4 WLH
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 *Course frequency:* each winter semester	
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	5 C

• Understanding the read only data store architecture	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Sven Bingert
Course frequency: each summer 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.1248: Language as Data**	6 C 4 WLH

Learning outcome, core skills: After completion of this module, students can • make appropriate use of terminology and explain theoretical concepts to describe characteristics of language data • describe foundational knowledge of representation learning for language data • apply language technology software to text datasets and interpret the output • discuss limitations of language models and their ethical implications	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Language as Data (Lecture)	2 WLH
Examination: Written exam (90 minutes) or oral exam (20 minutes) **Examination prerequisites:** Successful participation in exercise **Examination requirements:** Students need to achieve the learning goals	6 C

Course: Language as Data - Exercise (Exercise)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** Python programming skills
Language: English	**Person responsible for module:** Prof. Dr. Lisa Beinborn
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 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-Silviu 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.1903: Applied Language and Text Processing	6 C 4 WLH
Learning outcome, core skills: Nach dem Bestehen des Moduls ist der/die Teilnehmer:in befähigt zum: • Analysieren der Anforderungen einer spezifischen Anwendung • Auswählen und Anwenden gängiger Verfahren für eine Verarbeitungsaufgabe • Entwerfen komplexer Verarbeitungspipelines • Planen eines kleineren Projektes im Team • Auswerten und Einordnen der Ergebnisse	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Sprach- und Textanalyse in der Praxis (Exercise, Seminar) *Contents*: Die Studierenden lernen in Kleingruppen, Verfahren der computationellen oder manuellen Sprach- und Textanalyse zu entwickeln und an einem Fallbeispiel anzuwenden und zu evaluieren. Sie lernen geeignete Daten zu finden, auszuwählen und aufzubereiten. Sie erwerben ein Verständnis für die Schwierigkeiten, die bei der Arbeit mit authentischen Daten entstehen können und entwickeln Lösungsstrategien. Die Studierenden üben die Anwendung von algorithmischen Verfahren und die Erarbeitung und kritische Evaluation komplexer Anwendungspipelines. Sie lernen ebenso die Zusammenarbeit in einer Gruppe.	4 WLH
Examination: Referat (max 30 Min.) und Hausarbeit (max. 12 Seiten) **Examination prerequisites:** Teilnahme an Seminar und Übung **Examination requirements:** Die Studierenden weisen nach, dass Sie die Anforderungen einer spezifischen Text-/Sprachverarbeitungsaufgabe analysieren und geeignete Verfahren auswählen und anwenden können. Sie können zudem ein Projekt im Team planen und komplexe Verarbeitungspipelines entwerfen sowie die Ergebnisse auswerten und einordnen.	6 C

Admission requirements: none	**Recommended previous knowledge:** Wissen über grundlegende Sprachverarbeitungsaufgaben und -algorithmen (Tokenisierung, Wortartenerkennung, syntaktische Analyse) ist sinnvoll und kann z.B. durch den Besuch einer entsprechenden Einführungsveranstaltung oder die Arbeit mit einem einschlägigen Lehrbuch erworben werden. Elementare Programmierkenntnisse (in irgendeiner Programmiersprache) können hilfreich sein, sind aber nicht zwingend erforderlich.
Language: German, English	**Person responsible for module:** Prof. Dr. Caroline Sporleder
Course frequency:	**Duration:**

each winter semester	1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module B.Inf.1904: Introduction to Computational Linguistics and Natural Language Processing**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
A successful completion of the module enables the participants to: • describe typical language analysis tasks • illustrate suitable methods for different language analysis tasks • apply elementary language analysis algorithms • compare the advantages and disadvantages of different methods • sketch methods for measuring the quality of data annotation performed by humans and algorithms • construct complex problem solving pipelines (data selection, annotation, analysis and evaluation of the results) • select suitable algorithms for specific application scenarios	Attendance time: 56 h Self-study time: 124 h

Course: Introduction to Computational Linguistics and Natural Language Processing (Lecture, Exercise)	4 WLH
Contents: The course provides an overview of the main tasks and challenges in computational linguistics and natural language processing. Students are introduced to standard algorithms for analysing natural language, covering the areas lexicon, syntax, semantics and discourse. The course highlights the underlying assumptions and strategies of different methods as well as their advantages and disadvantages in different application scenarios. The students learn to develop approaches for solving text and language processing tasks, taking into account data selection, annotation, analysis and evaluation of the results.	
Examination: Written exam (90 minutes) or oral exam (20 minutes) **Examination prerequisites:** Participation in the exercise **Examination requirements:** The students demonstrate knowledge of specific computational linguistic tasks, methods and research results and are able to understand and reflect to some extent on methods and theories in computational linguistics. They are able to: • describe typical language analysis tasks • illustrate suitable methods for different analysis tasks • apply elementary language analysis algorithms • compare the advantages and disadvantages of different methods • select suitable algorithms for specific application scenarios	6 C

Admission requirements:	**Recommended previous knowledge:**
none	none
Language: English, German	**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: 30	

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:** Studiendekan*in

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

- kennen die wichtigsten elementaren stochastischen Grundmodelle und 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 mehrdimensionalenVerteilungen;
- beschreiben Wahrscheinlichkeitsmaße mit Hilfe von Verteilungsfunktionen bzw. Dichten;
- verstehen und nutzen das Konzept der Unabhängigkeit;
- berechnen 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 und beweisen 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 und zu beweisen.	

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:** Studiendekan*in
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	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

Course: Numerische Mathematik II - Übung	2 WLH

Examination requirements: Nachweis weiterführender Kenntnisse in numerischer Mathematik	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1300
Language: German	**Person responsible for module:** Studiendekan*in
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:	**Workload:**
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.	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.0012, B.Mat.0021
Language: German	**Person responsible for module:** Studiendekan*in
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 Methoden und Denkweisen der Statistical Data Science vertraut. Sie • modellieren diskrete Wahrscheinlichkeitsräume, beherrschen die damit verbundene Kombinatorik sowie den Einsatz von Unabhängigkeit und bedingten Wahrscheinlichkeiten; • 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 elementare stochastische Beweistechniken und ihre Verwendung in der Statistical Data Science; • sind vertraut mit elementaren Schätzprinzipien wie etwa Maximum-Likelihood-Schätzer, Momentenschätzer und Bayes-Schätzer und kennen ihre elementaren statistischen Eigenschaften; • sind mit den zentralen Begrifflichkeiten zur Bewertung des Risikos dieser Schätzer vertraut; • erlernen algorithmische Verfahren der Statistical Data Science zur Berechnung dieser Schätzer; • sind mit grundlegenden mathematischen Methoden der Statistical Data Science vertraut, wie etwa Cluster-, 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 und diese mathematisch zu analysieren; • elementare stochastische Modelle der Statistical Data Science zu formulieren; • grundlegende Schätzmethoden zu verwenden und einfache Verfahren zur Cluster- und Regressionsanalyse mathematisch zu verstehen und 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:**	9 C

B.Mat.2420.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	

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.0011, B.Mat.0012
Language: German	**Person responsible for module:** Studiendekan*in
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 6
Maximum number of students: not limited	

Additional notes and regulations:

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

Georg-August-Universität Göttingen Module B.Phy.5601: Theoretical and Computational Neuroscience I	3 C 2 WLH
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.	**Workload:** Attendance time: 28 h Self-study time: 62 h
Course: Collective Dynamics Biological Neural Networks I (Lecture)	
Exactly one of the following examinations must be successfully completed:	
Examination: Written examination (120 minutes)	3 C
Examination: Oral examinationMündliche Prüfung (approx. 30 minutes)	3 C
Examination: Vortrag (2 Wochen Vorbereitungszeit) (30 minutes)	3 C
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	

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)	

Exactly one of the following examinations must be successfully completed:	
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.Phy.5676: Computer Vision and Robotics**	9 C 6 WLH

Learning outcome, core skills: After successful completion of this module, students are familiar with • the basic concepts of computer vision (CV), • low level hardware components and their functions, • building and programming a robot, and • computer vision and robotics algorithms.	**Workload:** Attendance time: 84 h Self-study time: 186 h

Course: Introduction to Computer Vision and Robotics (Lecture) *Contents*: On-Off Controller, PID Controller, Moving Average Filter, Exponential Moving Average Filter, Kalman Filter, A*, Dijkstra, RRT, Q-Learning , Inverse and Forward Kinematics, Movement Generation Methods, Smoothing and Median Filtering, Bilateral Filtering, Non-Local Means, Connected Components , Morphological Operators , Line Detection, Circle Detection, Feature Detection, Advanced image segmentation algorithms.	2 WLH
Course: Practical Course on Computer Vision and Robotics (Lecture) *Contents*: Building a robot, solving a graph problem using the robot and executing the found solution by the robot in a real-world scenario involving perception and navigation	2 WLH
Course: Tutorial on Computer Vision and Robotics (Tutorial) *Contents*: In the accompanying tutorial sessions students deepen and broaden their knowledge from the lectures	2 WLH
Examination: Written report (approx. 10 p.) and Oral Exam (approx. 30 minutes) **Examination requirements:** Written report requirements: The students must be able • to describe their project in a written report • to explain given problems and used solutions for navigation- and perception problems of robots Oral Examination requirements: The students must be able • to repeat and explain lecture material • to explain control algorithms for a robot, and • to identify and understand low level hardware components as robot sensors and actuators.	9 C

Admission requirements: none	**Recommended previous knowledge:** Programming in Python
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:	**Recommended semester:**

three times	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 (90 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: none	**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 B.WIWI-BWL.0004: Production and Logistics**	6 C 4 WLH
Learning outcome, core skills: The students • are able to classify production and logistics processes in a business environment, • are able to differentiate and characterize subareas of logistics, • know the basics of production program planning, • can solve production program planning problems using linear optimization and interpret the results in a business environment, • know the basics and aims of order planning and scheduling, • know subareas of distribution planning and are able to relate to them in a differentiated manner, • are able to apply several methods of transportation and location planning on simple problems.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Production and Logistics (Lecture) *Contents*: The lecture aims to provide students with an overview of operational production processes and the close integration of production and logistics. Planning approaches to efficiently organize business processes are introduced, including some from production and cost theory, production program planning, procurement and production logistics as well as distribution logistics. In the associated tutorials, the students learn to apply quantitative methods, e.g. the Simplex algorithm, Gozinto graphs, and methods for the planning of procurement, sequential production, transport and location.	2 WLH
Course: Production and Logistics (Tutorial) *Contents*: In the tutorials, method applications are taught, in particular simplex algorithms, Gozinto graphs and methods for order planning, process planning, transport and location planning.	2 WLH
Examination: Written examination (60 minutes)	6 C
Examination requirements: In the module exam, the students prove knowledge in the following areas: • Production and cost theory • Production program planning • Deployment planning / procurement logistics • Implementation planning / production logistics • Distribution logistics • Simulation and visualization of production and logistics processes • Application of basic algorithms of Operations Research and linear optimization on the problems mentioned above	

Admission requirements: none	**Recommended previous knowledge:** B.WIWI-OPH.0002 Mathematics

Language: German	**Person responsible for module:** Prof. Dr. Matthias Schulz
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 5
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module B.WIWI-BWL.0005: Marketing	6 C 4 WLH
Learning outcome, core skills: Students become acquainted with the objectives, framework conditions and decisions relating to all areas of the marketing mix. Moreover, they should understand the basics of consumer behaviour and market research. Building on this, students should be able to analyze strategic decisions within a company and assess the effects of the marketing mix in a theory-based way.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Marketing (Lecture) *Contents*: 1. Conceptual basics of marketing 2. Marketing decisions and management cycle 3. Analysis of consumer behavior • Principles of buying behaviour • Purchasing processes of consumers • Purchasing processes in companies 4. Market research • Principles of market research • Methods of data collection • Methods of data evaluation 5. Marketing objectives and strategies 6. Product and product mix decisions • Foundations • Decision areas • Brand management 7. Pricing decisions • Foundations • Price setting mechanisms with marginal analysis • Price differentiation and price bundling 8. Communication decisions • Defining communication • Communication process 9. Distribution decisions • Design of the sales system • Logistic	2 WLH
Course: Marketing (Exercise) *Contents*: Revising and enlarging upon contents of the lecture with case studies and exercises.	2 WLH

Examination: Written examination (90 minutes)	6 C
Examination requirements: Students should be able to understand strategical marketing mix decisions, fundamentals of market research and consumer behavior.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Waldemar Toporowski
Course frequency: each semester; in the summer term as a recording	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 4
Maximum number of students: not limited	

Additional notes and regulations:
Recordings from winter term are used for the summer semester.

Georg-August-Universität Göttingen **Module B.WIWI-EXP.0001: Introduction to Business Economics and Entrepreneurship**	6 C 3 WLH
Learning outcome, core skills: After successfully completing this course, the students have a basic knowledge about fundamental topics of Business Economics as a science (e.g. Management, Organization, Human Resources, Legal, Business Combinations, Procurement, Production, Distribution, and Finance). Furthermore, the students have knowledge about the process of business creation and assess the importance of economic principles.	**Workload:** Attendance time: 42 h Self-study time: 138 h
Course: Introduction to Business Economics and Entrepreneurship (Lecture) *Contents*: 1. Company and Management 2. Function of the management 3. Organization, human resources management, control, information management and controlling 4. Consecutive decisions of companies 5. Sales management and marketing 6. Production and procurement management 7. Finance 8. Accounting 9. Entrepreneurship and business start-up - what to do?	2 WLH
Course: Introduction to Business Economics and Entrepreneurship (Exercise) *Contents*: Within the associated tutorials, the students will deepen the contents of the lecture through sample calculations and case studies.	1 WLH
Examination: Written examination (90 minutes)	6 C
Examination requirements: Students are expected to prove their theoretical knowledge of basic economic terms and to know basic problems and solution approaches of economic subfields. Furthermore, knowledge in the field of business creation are requested. The students must also be capable to apply theoretical contents in smaller case studies and tasks.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Stefan Dierkes
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students:	

not limited	

<table>
<tr><td>Georg-August-Universität Göttingen
Module B.WIWI-OPH.0004: Corporate Finance</td><td>6 C
4 WLH</td></tr>
</table>

<table>
<tr><td>Learning outcome, core skills:
After successfully completing this module students should be able to
• understand and being able to explain the different functions of corporate finance within a firm according to the traditional and modern views.
• explain and correctly apply the basic terminology of corporate finance.
• explain and critically reflect the economic foundations of investment theory.
• explain and apply major methods and criteria for investment evaluation (net present value methods, future value method, annuity method, internal rate of return, pay-back method).
• put structure to decision problems under uncertainty.
• explain and distinguish between different forms of financing and be able to critically assess their potential strengths and weaknesses.
• explain the concepts of cost of capital and leverage and be able to illustrate their importance for corporate finance.</td><td>Workload:
Attendance time:
56 h
Self-study time:
124 h</td></tr>
</table>

<table>
<tr><td>Course: Corporate Finance (Lecture)
Contents:
1. The traditional view on corporate finance
2. The modern view on corporate finance
3. Foundations of investments
4. Capital budgeting and investment criteria
5. Decision problems under uncertainty
6. The cost of capital for equity and debt
7. Capital structure and the cost of capital</td><td>2 WLH</td></tr>
<tr><td>Course: Corporate Finance (Tutorial)
Contents:
In accompanying tutorials students deepen and extend their knowledge and skills.</td><td>2 WLH</td></tr>
<tr><td>Examination: Written examination (60 minutes)</td><td>6 C</td></tr>
</table>

<table>
<tr><td>Examination requirements:
• Knowledge of the role and function of corporate finance according to the traditional and modern views.
• Knowledge of the basic terminology of corporate finance and ability to apply this terminology correctly.
• Knowledge of the economic foundations of investment theory.
• Ability to describe, differentiate between, and correctly apply the major investment criteria.
• Show understanding of the basic concepts to structure and solve decision problems under uncertainty.
• Ability to describe and differentiate between different forms of financing and to assess their advantages and disadvantages.</td><td></td></tr>
</table>

• Knowledge of the concepts of cost of capital and leverage and ability to explain their importance.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Olaf Korn Prof. Dr. Benedikt Downar
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 2
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.Agr.0052: Ecology and Nature Conservation**	6 C 6 WLH
Learning outcome, core skills: Die Studierenden sollen die Lebensraumtypen und Lebensgemeinschaften der Agrarlandschaften so kennenlernen, dass sie Bewertungen unter Naturschutzgesichtspunkten vornehmen können. Dazu gehört ein tiefes und interdisziplinäres Verständnis von Biodiversitätsmustern und ökologischen Prozessen, wie sie nur durch eine Integration von Ökologie, Umweltökonomie, Nutzpflanzen- und Nutztierwissenschaften erfolgen kann. Zudem werden statistische Fertigkeiten erworben, die für den Test komplexer Fragestellungen wichtig sind.	**Workload:** Attendance time: 79 h Self-study time: 101 h
Course: Bewertung und Pflege von Lebensräumen (Exercise, Seminar) *Contents*: Charakterisierung der Lebensräume der Agrarlandschaft, biologische Schädlingsbekämpfung und Räuber-Beute-Beziehungen, Biotopvernetzung und genetische Differenzierung isolierter Populationen, Versuchsplanung bei ökologischen Fragestellungen, Landschaftsplanung und Biotopbewertung, interdisziplinäre Perspektive auf Fragen der umweltfreundlichen Agrarproduktion, naturschutzgerechten Landschaftsplanung und Ressourcenmanagements.	4 WLH
Examination: Präsentation, Referat oder Korreferat (Gewicht: 60%, Dauer: ca. 20 Minuten) und Hausarbeit (Gewicht: 40%, Umfang: max. 25 Seiten) **Examination prerequisites:** Teilnahme an den praktischen Übungen, Anwesenheitspflicht, max. 2 Fehltermine **Examination requirements:** Interdisziplinäre Sichtweise auf Probleme im Spannungsfeld von Landwirtschaft und Naturschutz	3 C
Course: Landwirtschaft und Naturschutz (Seminar) *Contents*: Interdisziplinäre Perspektive auf Fragen der umweltfreundlichen Agrarproduktion, naturschutzgerechten Landschaftsplanung und des Ressourcenmanagements in multifunktionalen Agrarlandschaften.	2 WLH
Examination: Präsentation (ca. 20 Minuten) **Examination prerequisites:** Teilnahme an den praktischen Übungen, Anwesenheitspflicht, max. 2 Fehltermine **Examination requirements:** Grundlegende Kenntnisse im Bereich der Bewertung und Pflege von Lebensräumen.	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English, German	**Person responsible for module:** Prof. Dr. Catrin Westphal
Course frequency:	**Duration:**

each winter semester	1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.Agr.0061: Practical Course Nature Conservation in Agricultural Landscapes**	6 C 4 WLH
Learning outcome, core skills: Die Studierenden sollen lernen, wie man sich selbständig eine innovative Fragestellung erarbeitet und wie ein Versuchsdesign ausschauen kann, das zur Beantwortung dieser Frage geeignet ist. Die Erfahrung mit selbständiger Anlage und Auswertung von Experimenten ist eine elementare Grundlage für wissenschaftliches Arbeiten, wie es letztlich bei der Masterarbeit gefordert ist. Zudem erlaubt die kritische Diskussion der Vorgehensweise, die Glaubwürdigkeit von wissenschaftlichen Arbeiten und Gutachten besser zu beurteilen.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Projektpraktikum Naturschutz in der Agrarlandschaft (Internship, Seminar) *Contents*: Selbständige Erarbeitung von Problemstellungen und Versuchen zur Fragen des Naturschutzes in der Agrarlandschaft. Die Studierenden erarbeiten eine innovative Fragestellung und ein zum Testen der jeweiligen Hypothesen geeignetes Versuchsdesign. Der Versuchsplan wird im Plenum vorgestellt und diskutiert. Die Feld- und Laborexperimente finden danach weitgehend selbständig statt. Die statistische Auswertung der Ergebnisse wird Teil eines Protokolls, das wie eine wissenschaftliche Arbeit aufgebaut sein soll (Einleitung, Methoden, Ergebisse, Diskussion). Bei allen Schritten findet eine intensive Betreuung und Anleitung statt.	4 WLH
Examination: Hausarbeit (max. 20 Seiten, 70%) und Präsentation, Referat oder Korreferat (ca. 15 Minuten, 30%) **Examination requirements:** Erfahrung mit selbständiger Anlage und Auswertung von Experimenten. Kenntnisse zur statistischen Auswertung der gewonnen Ergebnisse. Referat: In einem 12-minutigen Referat werden die Ergebnisse der Felduntersuchungen präsentiert und kritisch diskutiert. Dies beinhaltet neben einer kurzen Einleitung die Darstellung der Untersuchungshypothesen, Feld-/Labormethoden, statistische Datenauswertung und eine Diskussion der Ergebnisse unter Einbeziehung von Sekundärliteratur, wie z.B. wissenschaftlichen Fachpublikationen (30% der Modulnote). Hausarbeit: In einer schriftlichen Hausarbeit (Umfang max. 20 Seiten) werden die Versuche im Stil einer wissenschaftlichen Veröffentlichung dargelegt. Die Hausarbeit wird hierbei gegliedert in: Zusammenfassung, Einleitung, Hypothesen, Methoden, Resultate, Diskussion und Quellen. Neben formalen Aspekten (z.B. Darstellung der Ergebnisse, Orthografie, korrekte Zitierweise) steht insbesondere die Diskussion der eigenen Ergebnisse unter Berücksichtigung der wissenschaftlichen Fachliteratur im Fokus der Prüfungsanforderungen (70% der Modulnote).	6 C

Admission requirements: none	Recommended previous knowledge: none
Language: German	**Person responsible for module:** Prof. Dr. Catrin Westphal

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.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 or key competence module M.Bio.172.	**Recommended previous knowledge:** • Watson, Molecular Biology of the Gene, Pearson, 7th 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. 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 Statistics 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 (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: basic computer knowledge, basic experience in coding	**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.340: Systems biology**	3 C 2 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: 42 h Self-study time: 48 h

Course: Bioinformatics in systems biology (Lecture)	2 WLH
Examination: Oral examination (approx. 30 minutes)	3 C

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

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Tim Beißbarth
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.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.CoBi.504: Comparative and Evolutionary Genomics**	12 C 14 WLH
Learning outcome, core skills: Students will acquire an understanding of the usage and usefulness of comparative approaches in analyzing large-scale biological data (foremost sequencing data). This will entail a hands-on experience with carrying out comparative analyses on genomic data. The students will learn how to analyze, evaluate, and present comparative data. Furthermore, students will read, present, and critically discus published comparative studies that cover current topics in comparative. evolutionary and population genomics. Main topics are: comparative genomics: more than evolutionary biology, introduction to evolutionary/tree thinking, the evolutionary forces that shape genomes, a common language for comparisons (ontologies, pathways and more), reconciliation of gene families and species trees, forward and reverse genetics in light of comparative genomics, major evolutionary transitions gleaned from genomics, phylogenomics, reticulate evolution. Students will acquire an understanding on the principles and concepts important for population genomic analyses and inferences.	**Workload:** Attendance time: 196 h Self-study time: 164 h
Course: Comparative and Evolutionary Genomics (Lecture) *Contents*: principles of evolutionary thinking,evolutionary concepts,analyses and useful software for comparative genomic analyses,phylogenomics,ancestral character state reconstruction, Evolutionary processes in populations, Population genetic and genomic analyses, interpretation of data	4 WLH
Examination: protocol (10-20 pages; 70% of final grade); oral presentation in seminar(25 min + 20 min discussion; 30% of final grade) **Examination prerequisites:** regular attendance and active participation **Examination requirements:** Detailed knowledge on macro-evolutionary processes, evolutionary thinking, methods available to compare genomic data, background on methods to analyse comparative evolutionary questions with genomic data, interpretation of results	12 C
Course: Genomic insights into evolutionary processes (Seminar) *Contents*: reading and presenting a published article on comparative, evolutionary and/or population genomics, discussion among all participants on the presented work, feedback on presentation, discussions around evolutionary thinking	3 WLH
Course: Applying Comparative and Evolutionary Genomics (Internship)	7 WLH

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Jan de Vries
Course frequency:	**Duration:**

each winter semester	1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.CoBi.507: Computational Biomedicine**	6 C 4 WLH
Learning outcome, core skills: After attendance, students will be familiar with common techniques applied in computational biomedicine and will be able to perform basic research projects within the subject. Specific topics are: - Pattern recognition in disease - Computational biomarker discovery - Single- and multi-omics analysis - Computational methods for single-cell analysis: dimension reduction, pseudo-time, and downstream analyses - Cancer evolution modeling - Signal transduction and modeling The tutorials will enable students to perform basic analyses covering these topics in R or python.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Computational Biomedicine Lecture *Contents*: - Pattern recognition in disease - Computational biomarker discovery - Single- and multi-omics analysis - Computational methods for single-cell analysis: dimension reduction, pseudo-time, and downstream analyses - Cancer evolution modeling - Signal transduction and modeling	2 WLH
Examination: Oral examination (approx. 30 minutes) **Examination prerequisites:** 50% of homeworks **Examination requirements:** requirements are a solid understanding of common omics data including single-cell and spatial omics, a basic understanding of computational concepts and their implementation, and familiarity with computational approaches for, e.g., pattern recognition, biomarker discovery, single-cell analysis, cancer evolution, and network inference.	
Course: Computational Biomedicine Tutorial *Contents*: Specific topics are: - Pattern recognition in disease - Computational biomarker discovery	2 WLH

- Single- and multi-omics analysis - Computational methods for single-cell analysis: dimension reduction, pseudo-time, and downstream analyses - Cancer evolution modeling - Signal transduction and modeling The tutorials will enable students to perform basic analyses covering these topics in R or python.	

Examination requirements: requirements are a solid understanding of common omics data including single-cell and spatial omics, a basic understanding of computational concepts and their implementation, and familiarity with computational approaches for, e.g., pattern recognition, biomarker discovery, single-cell analysis, cancer evolution, and network inference.	

Admission requirements: None	**Recommended previous knowledge:** Basic programming knowledge in R or Python. Basic knowledge in statistics.
Language: English	**Person responsible for module:** Prof. Dr. Michael Altenbuchinger
Course frequency: each winter semester1	**Duration:**
Number of repeat examinations permitted: twice	**Recommended semester:** from 1
Maximum number of students: 30	

Additional notes and regulations: Bemerkungen extern de

Georg-August-Universität Göttingen **Module M.CoBi.541: Bioinformatics and its areas of application**	4 C 3 WLH

Learning outcome, core skills: The students will acquire knowledge on a diverse range of topics - both applied as well as purely bioinformatical. For this, there will be research-oriented lectures. On the applied side, these topics prominently feature - but are not limited to - the different types of "omics"-approaches available to answer biological questions (genomics, transcriptomics, phylogenomics, metabolomics, proteomics, CHIP-Seq, comparative genomics, phenomics etc). They will learn about feasibility and different approaches to data analysis. Furthermore, students will learn about the digitization of the biological sciences, featuring aspescts such as machine readable phenotypic annotation of morphology, phenotypic database, biological image analysis and more. Finally, the students will acquire knowledge on algorithmic and statistical aspects of bioinformatics, featuring the latest developments and challenges in the development of new bioinformatic tools for life sciences.	**Workload:** Attendance time: 42 h Self-study time: 78 h

Course: Bioinformatics and its areas of application (Lecture) *Contents*: This course provides an appetizer of the various applications and uses of bioinformatics - especially those represented by research on Göttingen Campus.	3 WLH
Examination: Term Paper (max. 10 pages), not graded **Examination requirements:** Students show that they gained an overview of the diversity of areas of application for algorithmic and applied bioinformatics - including tools for computational biology to solve biological questions - as well as in depth knowledge on a topic of choice for the essay.	4 C

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

Georg-August-Universität Göttingen **Module M.CoBi.572: Biology for Bioinformaticians**	8 C 6 WLH
Learning outcome, core skills: This course aims to teach the principles of biology required for aspiring bioinformaticians and computational biologists. The students will learn about the basics of the building blocks of life. An introduction to molecular biology will cover aspects of cell biology, developmental biology, principles of genetics and genome biology, microbiology, protein biology and enzymology, and biochemistry as well as metabolism. Furthermore, they will get a glimpse into biodiversity through an introduction organismal diversity across uni- and multicellular life. This will be contextualized by a basic (molecular) evolutionary biological framework.	**Workload:** Attendance time: 84 h Self-study time: 156 h
Course: Biology for (bio)informaticians	4 WLH
Examination: Written examination (90 minutes)	8 C
Course: Biology for (bio)informaticians Tutorial (Tutorial)	2 WLH
Examination requirements: knowledge of the basics in molecular biology (cell biology, microbiology, genetics, neurobiology, developmental biology, biochemistry) as well as biodiversity (microorganisms, plants, fungi, animals)	

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

Georg-August-Universität Göttingen Module M.DH.016: Multimodality	9 C 4 WLH

Learning outcome, core skills: Die Studierenden • können textuelle und audio-visuelle Äußerungen in ihre Verwendungskontexte, den historischen Diskurs oder die moderne Forschungssituation einbinden; • kennen Möglichkeiten der digitalen Vermittlung zwischen den “stummen” Artefakten und den historischen oder zeitgenössischen Verhältnissen; • besitzen die Fähigkeit, die Bedeutung historischer, kultureller oder aktueller Kontexte mit digitalen Methoden zu analysieren und in einer grundsätzlichen Methodenreflexion zu diskutieren; • sind in der Lage, die wissenschaftliche Kategorisierungen von Personen, Bildern und Objekten, Räumen, Vorstellungen oder Prozessen digital zu modellieren und zueinander in Beziehung zu setzen; • sind imstande, die verwendeten Lösungsansätze in Hinblick auf ihre wissenschaftlichen, gesellschaftlichen und ethischen Folgen zu bewerten und das analytische Wissen reflexiv auf sich selbst und ihr Handeln anzuwenden.	**Workload:** Attendance time: 56 h Self-study time: 214 h

Course: Übung	2 WLH

Course: Seminar	2 WLH
Examination: Referat (ca. 30 Min.) mit schriftlicher Ausarbeitung (max. 15 Seiten) **Examination prerequisites:** erfolgreiche digitale Umsetzung der gestellten Übungsaufgaben. **Examination requirements:** Die Studierenden reflektieren Ergebnisse der Visual Culture Studies und der Multimodalitätsforschung und besitzen die Fähigkeit, Methoden und Theoriebildungen zu evaluieren und in Ansätzen zu modifizieren. Die Prüfung ist im Seminar zu erbringen.	9 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Martin Gustav Langner Prof. Dr. Jörg Wesche
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 Computational 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:** Dr. Anna Dorofeeva
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 Computational 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 Gustav 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.14: Theories and Research Questions in Computational 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 Gustav 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.15: Theories and Research Questions in Computational 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 Gustav 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.17: Digital Palaeography in Theory and Practice	9 C 4 WLH

Learning outcome, core skills:	**Workload:**
Die Studierenden • haben einen Überblick über Methoden und Forschungsfragen der digitalen Paläographie; • kennen computergestützte Verfahren zur Erschließung, Aufbereitung, Analyse und Präsentation von Handschriften; • sind auch mit verschiedenen Schriftformen vertraut; • kennen Möglichkeiten der digitalen Vermittlung zwischen den Manuskripten und den historischen oder zeitgenössischen Verhältnissen sowie der Analyse ihrer Bedeutungen und besitzen die Fähigkeit, diese in einer grundsätzlichen Methodenreflexion zu diskutieren; • sind imstande, die verwendeten Lösungsansätze zu bewerten und das analytische Wissen reflexiv auf sich selbst und ihr Handeln anzuwenden; • sind in der Lage, die wissenschaftlichen, gesellschaftlichen und ethischen Kategorisierungen von Personen, Texten, Räumen, Vorstellungen oder Prozessen digital zu modellieren, zu reflektieren und visuell zueinander in Beziehung zu setzen.	Attendance time: 56 h Self-study time: 214 h

Course: Übung	2 WLH

Course: Seminar	2 WLH
Examination: Referat (ca. 30 Min.) mit schriftlicher Ausarbeitung (max. 15 Seiten) **Examination prerequisites:** regelmäßige Teilnahme am Seminar sowie erfolgreiche digitale Umsetzung der gestellten Übungsaufgaben. **Examination requirements:** Die Studierenden reflektieren Ergebnisse spezifisch paläographischer Forschung und besitzen die Fähigkeit, Methoden und Theoriebildungen zu evaluieren und in Ansätzen zu modifizieren. Die Prüfungsleistung ist im Seminar zu erbringen.	9 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Anna Dorofeeva
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 4
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.FES.111: Introduction to Ecological Modelling**	6 C 4 WLH

Learning outcome, core skills: Basic knowledge of classic and modern approaches for modelling dynamics of populations and communities. Skilled in analytical thinking, independent application of models for practical research questions, development of simple models, and critical assessment of the possibilities and limitations of different modeling approaches. Ability to develop an effective model concept.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Introduction to ecological modelling (Lecture, Exercise) *Contents*: Using examples from ecology in general and forest ecology in specific, we will cover the following modelling approaches and types: population growth (considering demographic and environmental noise, scramble and contest competition), metapopulation models, predator-prey models, forest growth models, patterns and dynamics of biodiversity, island biogeography, life tables, matrix models, individual-based models, and spatial models. We will also address how to develop a model concept. The course will consist of a mixture of lectures and hands-on work on the computer.	4 WLH
Examination: Term paper (max. 3 pages, 50%) and written examination (45 minutes, 50%)	6 C

Examination requirements: Term paper: Ability to develop an effective model concept. Written examination: Knowledge and understanding of essential characteristics of the modelling approaches covered in class. Ability to interpret model results. Knowledge of possibilities and limitations of the models.	

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

Georg-August-Universität Göttingen Module M.FES.114: Ecosystem - Atmosphere Processes	6 C 4 WLH
Learning outcome, core skills: Understanding the carbon and water cycle of terrestrial ecosystems requires a solid understanding of biogeophysical and biogeochemical processes at the ecosystem – atmosphere interface. These processes are directly affected by human induced alterations of the climate system such as climate change and land use. In this course, the students will learn about ecosystem – atmosphere processes based on real datasets from forests and other terrestrial ecosystems. The student will be exposed to a quantitative analysis of the data and will gain basic insights into land surface modelling considering land use as well as climate change.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Ecosystem – Atmosphere Processes (Exercise)	2 WLH
Course: Ecosystem – Atmosphere Processes (Lecture, Seminar)	2 WLH
Examination: Presentation (approx. 20 minutes, 50%) and oral exam (approx. 20 minutes, 50%)	6 C
Examination requirements: The student will learn about biogeophysical and biogeochemical processes at the ecosystem – atmosphere interface. They will have the ability to formulate these processes in the programming language R and describe them quantitatively.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Nils Knohl
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.FES.122: Ecological Simulation Modelling**	6 C 4 WLH
Learning outcome, core skills: • Knowledge of the modelling techniques covered; • Ability to find a suitable modeling technique for a given problem in the area of ecology and to apply it independently; • Knowledge of the current state of research in ecological modelling; • Critical appreciation and discussion of research results; • Refined presentation techniques; • Knowledge of constructive feedback techniques.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Simulation Modelling (Lecture, Exercise)	3 WLH
Course: Current Topics in Ecological Modelling (Seminar)	1 WLH
Examination: Presentation (approx. 15 min) with written outline (max. 10 pages) **Examination prerequisites:** Presentation (approx. 15 Minutes), ungraded	6 C
Examination requirements: • Know, explain, apply, analyse and assess model types that are applied in ecology • Know, explain, apply, analyse and assess the stages of model development along the modeling cycle • Present, explain and critically reflect a self developed simulation model • Understand and summarize published model studies and point out and discuss their possibilities and limitations	

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

Additional notes and regulations:

20 students are only possible if a corresponding number of computers is available.

Module is also applicable for other study programs, such as MSc "Biological Diversity and Ecology", MSc "Agriculture" (specialization Ressourcenmanagement).

Georg-August-Universität Göttingen **Module M.FES.124: Modern Concepts and Methods in Macroecology and Biogeography**	6 C 4 WLH
Learning outcome, core skills: The course will introduce students to the principles and modern methods in macroecology and biogeography. Students will gain a comprehensive understanding of the physical and biological processes influencing species distributions and diversity patterns worldwide. Additionally, students will be introduced to modern environmental and biodiversity modelling methods in R, which are important for analyzing and understanding the consequences of global change on species distributions. In self-directed projects, students will work with real data to solve modern macroecological problems. Through these theoretical and practical classes, students will gain a profound understanding of modern macroecological and biogeographical concepts, including threats to biodiversity and conservation prioritization.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Modern Concepts and Methods in Macroecology and Biogeography (Lecture, Exercise) *Contents*: Exercise = Computer course (3 WHL) and Lectures (1 WHL)	4 WLH
Examination: Term Paper (max. 20 pages)	6 C
Examination requirements: Students can apply knowledge about modern concepts and methods in macroecology and biogeography. They demonstrate knowledge on how to plan, conduct and report on a macroecological analysis using modern computer software.	

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge in R is a central pre-requisite to attend this module
Language: English	**Person responsible for module:** Prof. Dr. Holger Kreft
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen Module M.FES.223: Experimental Bioclimatology	6 C 4 WLH
Learning outcome, core skills: The student will learn about measuring, analyzing and interpreting bioclimatological processes in terrestrial ecosystems such as air temperature, air humidity, wind velocity, air pressure, radiation and their impacts on CO2, water and energy fluxes. After a seminar part, the students will install a fully equipped meteological station and analyze the data and evaluate the meteorological conditions and ecosystem-atmosphere exchange processes of a site.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Experimental Bioclimatology (Exercise)	2 WLH
Course: Experimental Bioclimatology (Seminar)	2 WLH
Examination: Presentation (approx. 20 minutes, 25%) and term paper (max. 15 pages, 75%)	6 C
Examination requirements: Understanding of bioclimatological processes and how they are measured. Ability to work with meteorological instruments, analyse and interpret data.	

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

Georg-August-Universität Göttingen **Module M.FES.231: Project: Ecosystem Sciences**	12 C 2 WLH

Learning outcome, core skills: Using and applying modern methods in ecosystem sciences to work independently on a research project; autonomous acquisition of know-how and competencies for scientific problem solving; ability to interdisciplinary, strategic thinking; team work and organisation of tasks, scientific presentation and discussion; writing a final report in the style of a scientific article.	**Workload:** Attendance time: 28 h Self-study time: 332 h

Course: Project: Ecosystem Sciences (Seminar) *Contents*: Each topic will be proposed by a researcher from the Faculty of Forest Sciences and Forest Ecology who will then be the principal supervisor for this topic. To support an interdisciplinary character of the project, a second supervisor may come from a department different from that of the principal supervisor. A topic can be worked upon by a single student or by a team of two or three students. In the case of teamwork, the final report must contain sections which can be attributed to one individual author.	2 WLH
Examination: Presentation (approx. 20 minutes, 30 %) and term paper (max. 15 pages, 70%)	12 C

Examination requirements: Demonstration of ability to conduct, analyse and report on an independent scientific research project.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Nils Knohl
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**
Maximum number of students: not limited	

Additional notes and regulations: Will be coordinated by A. Knohl in the summer semester and by A. Polle in the winter semester

Georg-August-Universität Göttingen **Module M.FES.712: Bioclimatology and Global Change**	6 C (incl. key comp.: 6 C) 4 WLH

Learning outcome, core skills: Scientific basis of climate and climate change, trace gas budgets of soils and whole ecosystems and the potential to sequester carbon and nitrogen in managed and unmanaged terrestrial ecosystems.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Bioclimatology and Global Change (Lecture, Seminar) *Contents*: The module "Bioclimatology and Global Change" will introduce the students to the global climate system and its interaction with the biosphere. A lecture course will focus on the scientific basis of climate and climate change covering basic physical and chemical processes governing the climate system, climate zones, modelling as well as global and regional climate phenomena with a focus on tropical climates. A seminar course will highlight trace gas budgets of soils and whole ecosystems and their potential to sequester carbon and nitrogen in managed and unmanaged terrestrial ecosystems and their vulnerability to climate change. Using journal literature the students will work out oral presentations concerning current research topics concerning the global climate system and its interaction with the biosphere.	4 WLH
Examination: Oral exam (approx. 20 minutes, 50%) and oral presentation (approx. 20 minutes, 50%)	6 C

Examination requirements: Understanding the most relevant processes at the biosphere-atmosphere interface and of biogeochemical cycles. Being able to find, read, evaluate, and present scientific literature related to Global Change.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Alexander Nils Knohl
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.FES.726: Ecological Modelling with C++**	6 C 4 WLH
Learning outcome, core skills: • Implementing ecological questions in model structures • Independently develop simulation models • Programming with C++ • Proficiency in the use of software dedicated to programming C++ • Commenting and documenting program code	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Ecological modelling with C++ (Lecture, Exercise) *Contents*: The module conveys advanced knowledge of modelling ecological questions. The focus is on the implementation of ecological models with the programming language C++. The module covers the fundamentals of C++ to the degree necessary for the implementation of models. Programming skills are applied in an independent modelling project implementing an own model question. The modelling project is documented in the term paper.	4 WLH
Examination: Term Paper (max. 20 pages)	6 C
Examination requirements: Develop ecological questions and translate them into model structures; Read and understand C++; implement model independently.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Kerstin Wiegand
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**
Maximum number of students: 14	

Georg-August-Universität Göttingen **Module M.Forst.745: Deep Learning Application in Forestry**	6 C

Learning outcome, core skills:	**Workload:**
Die Satellitenerdbeobachtung hat sich zu einer Schlüssel-technologie im Waldmonitoring entwickelt. Mit dem europäischen Erdbeobachtungsprogramms Copernicus existiert ein Programm, das den Zugang zu zeitlichen hoch aufgelösten und frei verfügbaren Satellitenbildern ermöglicht und zwar weltweit. Neue Auswertungsmethoden sind erforderlich, um mit den riesigen Datenmengen umzugehen; maschinelles Lernen insbesondere Deep Learning bietet hier hervorragende Möglichkeiten. Im diesem Modul erlangen Studierende Schlüsselqualifikationen zum Einsatz von Deep Learning Algorithmen für forstliche Anwendungen, die aber auch übertragbar auf Anwendungen anderer Fachdisziplinen ist. Sie lernen die Grundsätze des Deep Learning sowie neuronaler Netze und ihrer Optimierung kennen. Sie entwickeln ein Verständnis dafür, welche Fragestellungen mit den Methoden des Deep Learning gelöst werden können und welche Methoden ausgewählt werden sollten. Nach Abschluss des Moduls sind die Studierenden in der Lage, Deep Learning Anwendungen frei in Python zu programmieren. Sie können existierende neuronale Netze eigenständig implementieren und mit großen Datenmengen umgehen. Die Studierenden lernen, in interkulturellen und interdisziplinären Teams zu arbeiten, unterschiedliche Perspektiven und disziplinäre Wissensgrundlagen einzuschätzen, und sie entwickeln ihre interkulturellen Kommunikationskompetenzen weiter.	Attendance time: NaN h Self-study time: NaN h

Course: Deep Learning Anwendungen im Forst (Block course, Exercise)	WLH
Examination: Präsentation (ca. 15 Minuten) mit schriftlicher Ausarbeitung (max. 12 Seiten)	6 C

Examination requirements:	
In der Projektarbeit zeigen die Studierenden ihre Kenntnisse in der Anwendung neuronaler Netze, indem sie eine Klassifizierungs-/Segmentierungsaufgabe zu individuellen Fragestellungen und Datensätzen eigenständig bearbeiten. Die Studierenden können Python-Skripte lesen, verstehen und durch eigene Programmierung für die Lösung der Aufgabe anpassen.	

Admission requirements: none	**Recommended previous knowledge:** Kenntnisse in einer Programmiersprache sind von Vorteil
Language: German	**Person responsible for module:** Dr. Nils Nölke
Course frequency: each winter semester	**Duration:**
Number of repeat examinations permitted: cf. examination regulations	**Recommended semester:**

Maximum number of students: 20	

Additional notes and regulations:

Vorbehaltlich der jeweils zur Verfügung stehenden Erasmus+ Mittel wird das Modul als „Blended Intensive Programme“ (BIP) gemeinsam mit den Universitäten Bordeaux (Frankreich) und Groningen (Niederlande) aus dem ENLIGHT Netzwerk an wechselnden Standorten angeboten.

Bei Durchführung als Blended Intensive Programme ist die maximale Anzahl Studierender auf 8 begrenzt.

Georg-August-Universität Göttingen Module M.Geg.02: Resource Utilisation Problems	6 C 4 WLH

Learning outcome, core skills: Die Studierenden können die Bedeutung der Ressourcen Boden und Wasser als Bestandteile von Ökosystemen und Lebensgrundlage des Menschen aufzeigen und das globale sowie regional differenzierte Ausmaß der Gefährdung und Degradation dieser Ressourcen benennen. Sie sind in der Lage, das DPSIR-Konzept, durch das die Beziehungen Drivers – Pressures – State – Impacts – Responses verdeutlicht werden können, auf verschiedene Ressourcennutzungsprobleme anzuwenden. Sie kennen die Reference Soil Groups der World Reference Base for Soil Resources, sowie die spezifischen Bodeneigenschaften und daraus resultierenden Nutzungsmöglichkeiten, –einschränkungen und Gefährdungen der verschiedenen Böden. **Modulinhalte:** Eigenschaften, Nutzungsmöglichkeiten und –probleme verschiedener Böden (mit Schwerpunkt auf feuchte Tropen und Subtropen sowie Trockengebiete), Boden-gefährdungen, Faktoren und Prozesse der Bodendegradation, Ursachen, Ausmaß und Arten der Bodendegradation in Europa, Desertifikation, regional differenzierte Auswirkungen des Klimawandels auf die Ressourcen Boden und Wasser, globale Verteilung von Wasserangebot und –nachfrage, Wasserverbrauch nach Sektoren, Wassermangel, Ursachen und Ausmaß von Problemen mangelnder Wasserqualität, regionale Unterschiede in der Versorgung mit sanitären Anlagen und sauberem Trinkwasser.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Ressourcennutzungsprobleme (Lecture)	2 WLH
Course: Ressourcennutzungsprobleme (Seminar) Inkl. Geländetage zur Bearbeitung einer Fragestellung im Rahmen eines kleinen Projekts.	2 WLH
Examination: Written examination (90 minutes) **Examination prerequisites:** Regelmäßige Teilnahme am Seminar; Referat mit schriftl. Ausarbeitung bzw. schriftlichem Beitrag zum Projektbericht oder Poster (ca. 30 Min., max. 20 S. bzw. 1 DIN A 0 Poster) **Examination requirements:** Die Studierenden erbringen den Nachweis, dass sie Probleme der Boden- und Wassernutzung überblicken und spezifische Degradationsursachen sowie -prozesse verstehen. Sie zeigen, dass sie geeignete situationsbezogene Verfahren des nachhaltigen Umgangs mit Böden und Wasser kennen. Die Erstellung des Beitrags zum Projektbericht oder die Postererstellung als Prüfungsvorleistung machen die Mitwirkung bei der Projektbearbeitung erforderlich.	6 C

Admission requirements: none	**Recommended previous knowledge:** Grundlagen der Bodengeographie

Language: German	**Person responsible for module:** Prof. Dr. Daniela Sauer
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** from 2
Maximum number of students: 42	

Georg-August-Universität Göttingen **Module M.Geg.17: Landscape Ecology**	6 C 4 WLH
Learning outcome, core skills: The students know the components of element, water and energy budgets and fluxes in landscapes, and the most important element cycles. They are familiar with assessing soil properties and soil distribution patterns in landscapes, and with the measurement of microclimatic parameters. The students are able to generate hypotheses on the mutual relationships relief-soils-microclimate, to develop appropriate strategies for testing their hypotheses and to apply them in practice. The students have the competency to work on a research question in small international, culturally diverse teams, in a creative and outcome-oriented way. Thereby, they appreciate diverse cultural backgrounds and different approaches to handle a task. They are able to reflect on these in a constructive way and to jointly develop strategies for solving their research questions.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Landscape-ecological methods (Lecture)	1 WLH
Course: Landscape-ecological theory (Lecture)	1 WLH
Course: Landscape-ecological project (Seminar) with project-type components to be carried out in small international teams including measurements in the field.	2 WLH
Examination: Presentation (ca. 30 Min.) with written report (max. 20 p.) or DIN A 0 poster **Examination prerequisites:** Presentation (ca. 30 Min.) with written report (max. 20 p.) or DIN A 0 poster	6 C
Examination requirements: The students proof that they are able to generate hypotheses on the mutual relationships relief-soils-microclimate, to develop appropriate strategies for testing their hypotheses, considering different perspectives, and to apply them in practice. They proof that they can collaborate in an international team, interpret, document, present, discuss their results, and critically reflect the applied methods and obtained outcomes.	

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

20	

Additional notes and regulations: .

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) *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	3 WLH

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.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) *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).	4 WLH

• 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: 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 (NTHPDA) (Seminar) *Contents*: 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. *Teaching und learning methods:* 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. *Remark:* If you like to prepare for the topic early, we can hand out a topic during the lecture free time before the term - just contact us.	2 WLH
Examination: Presentation (approx. 35 min.) and report (max. 15 pages) **Examination prerequisites:** Participation in the seminar **Examination requirements:** Presentation (50%) and report (50%)	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Julian Kunkel
Course frequency: each 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.1238: Scalable Computing Systems and Applications in AI, BigData and HPC**	5 C 3 WLH
Learning outcome, core skills: The students will be able to • Describe approaches for the development of scalable systems and applications • Sketch efficient algorithms and concepts • Analyze and summarize state-of-the-art concepts, tools and research papers • Deliver a technical presentation for a professional audience • Explore and apply concepts or tools to improve scalability for a selected use case • Quantify efficiency and scalability of selected use cases	**Workload:** Attendance time: 42 h Self-study time: 108 h
Course: Scalable Computing Systems and Applications in AI, BigData and HPC (SCAP) (Seminar) *Contents*: Performance is an important feature for large-scale data analysis. *Teaching und learning methods:* The module can be considered to consist of a seminar and small-scale practical that are connected by a specific topic. Students will first select a topic and use case, for instance, scalable AI, lock-free data structures, concept or tool. Then, during the term they will prepare a presentation and introduce the topic considering state of the art. Next, a student will realize an individual project by practically working on their topic. They have to evaluate performance and scalability, and then analyze and quantify the contribution of the respective tool. Students can choose on a big variety of topics, some involve concepts and tools. Typically, the evaluation requires some application and programming. More information is provided on the webpage. The results are presented in a final meeting. *Remark:* If you like to prepare for the topic early, we can hand out a topic during the lecture free time before the term - just contact us.	3 WLH
Examination: Presentation (15 min) and report (max 15 pages) on student project **Examination requirements:** Report (70%) and final presentation (30%)	5 C

Admission requirements: none	**Recommended previous knowledge:** • Linux Basics (you have used Linux and the Bash shell). We will provide a short crash course at the beginning of the course and link supplementary training material.
Language: English	**Person responsible for module:** Prof. Dr. Julian Kunkel

Course frequency: each 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.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.1252: Specialisation Practical Computer Science**	6 C 4 WLH
Learning outcome, core skills: Students will acquire in-depth knowledge in one of the following areas. • Software Engineering • Operating Systems • Compilers and Programming Languages • Embedded Systems • Mobile Edge Computing • Pervasive Computing	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Specialisation Practical Computer Science (Lecture) *Contents*: Place holder for a course of the professorship of practical computer science.	
Examination: Written examination (90 minutes)	6 C
Course: Seminar Practical Computer Science (Seminar) *Contents*: Place holder for a course of the professorship of practical computer science.	
Examination: Oral report with written elaboration (max. 20 pages)	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Studiendekan Informatik
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 100	

Georg-August-Universität Göttingen **Module M.Inf.1304: E-Health**	6 C 4 WLH
Learning outcome, core skills: 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.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: E-Health (Block course) *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. *Course frequency:* once a year	4 WLH
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:	**Person responsible for module:**

German, English	Prof. Dr. rer. nat. Dagmar Krefting Prof. Dr. Ulrich Sax
Course frequency: each winter semester	**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. *Course frequency:* once a year	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: each winter semester	**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.1309: Biomedical Signal and Image Processing	6 C 4 WLH
Learning outcome, core skills: The students • name and describe aims and typical tasks in biomedical signal and image processing. • name the relevant signal and imaging techniques in biomedicine and explain their essential characteristics. • describe essential mathematical and physical contexts – on an appropriate level - which are the basis for the introduced techniques. • explain concepts overarching the fields of signal and image processing, e.g. signal-to-noise ratio, sampling, quantization, system theory. • explain the fundamentals of signal and image processing in time, frequency and time-frequency domain. • explain typical use-cases, e.g. signal delineation and image segmentation, and explain encountered challenges • explain fundamentals of multiscale signal and image analysis. • apply each of the theoretical fundamentals in practical use cases with established software tools.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Biomedical Signal and Image Processing (Lecture, Seminar) *Contents*: Electrical biosignals in biomedicine and their digital representation; typical processing chain starting with signal acquisition, followed by filtering and feature extraction; sampling theorem, aliasing; Linear-time invariant systems and their properties; Time and frequency domain representations of signals, uncertainty principle on time-frequency transforms: Short-time Fourier Transform, Discrete Wavelet Transform, Continuous Wavelet Transform; Convolution Theorem. Radiological, nuclear-medicine, and optical procedures in medicine; 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, Numpy, Scipy, Matplotlib. The contents are adjusted to current developments. Literature is indicated at the start of each semester.	4 WLH
Examination: Practical exam ("praktische Prüfung") (80%) and presentation of results (ca. 30 min.) (20%) in the seminar. **Examination requirements:** By means of a practical examination, the students continuously work on programming assignments that form a larger seminar project. The practical examination can be conducted in groups. The regular assignment results have to be submitted, and presented in the seminar.	6 C

Grading criteria will be presented to the students at the start of the module. Detailed requirements are incorporated in the assignments.	

Admission requirements: none	**Recommended previous knowledge:** Students are expected to have sound knowledge in fundamentals of mathematics. They are expected to have programming experience.
Language: English	**Person responsible for module:** Prof. Dr. rer. nat. Dagmar Krefting Prof. Dr. rer. nat. Ulrich Sax
Course frequency: each summer semester	**Duration:** 1 Semester
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 25	

<table>
<tr><td>Georg-August-Universität Göttingen
Module M.Inf.1351: Work Methods in Health Research</td><td>5 C
3 WLH</td></tr>
<tr><td>Learning outcome, core skills:
The students...
• name and explain methods, structures, and aims of collaborative research organizations and explain their impact on global health research and health care.
• explain collaborative work methods in academic projects.
• explain the role of individual actors in collaborative research.
• describe the structure and organization of German and European scientific community in societies and associations and explain the benefit of said organization for (international) research as well as their own personal benefits.
• demonstrate said competencies in a seminar assignment.</td><td>Workload:
Attendance time:
42 h
Self-study time:
108 h</td></tr>
<tr><td>Course: Mögliche Lehrformen: Vorlesung, Übung, Seminar, Blockseminar
Contents:
Clinical Research Units, Collaborative Research Centers, German Centers for Health Research, TMF, GMDS, EFMI, IMIA. Tools for collaborative work, team-building, maintaining a team, self-assessment. The contents are continuously adjusted to current developments of the field. Sources are recommended at the beginning of each term.
Course frequency: once a year</td><td>3 WLH</td></tr>
<tr><td>Examination: Seminar paper (max. 10 pages) and seminar presentation (approx. 20 minutes)
Examination prerequisites:
regelmäßige Teilnahme bei Blockseminaren und bei Seminaren
Examination requirements:
The students describe, explain, and assess selected aspects of collaborative health research in detail. This may be based on literature or individual research. The student work may address a specific aspect of collaborative research or analyze actual collaborative work designs. Students may work in teams. They make use of suitable literature and acquire further sources. They document their results in a seminar paper (ten pages maximum) and present their results in the seminar (20 minutes). Requirements are specified in an assignment sheet. Detailed grading criteria are conveyed at the start of each semester.</td><td>5 C</td></tr>
</table>

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

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: After successful completion of the module, students • know the principles, paradigms, and challenges of data mining methods for multivariate statistical analysis in computational biology and bioinformatics • understand and recognize properties and potential problems of high-dimensional data spaces • know and implement methods for dimensionality reduction using concepts from statistics and linear algebra • can evaluate linear and non-linear dimensionality reduction with the ability to critically assess and interpret the results • apply vector and matrix computation techniques for the analysis of multidimensional data	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Data Mining in Bioinformatics (Lecture, Exercise)	2 WLH
Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Participation in the exercises and successful completion of three exercise sheets. **Examination requirements:** Students should be able to understand, specify, use, implement and evaluate methods for analysis of high-dimensional biological data and critically assess the limits of their applicability.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of molecular biology, linear algebra and statistics, scientific programming in Python.
Language: English	**Person responsible for module:** Dr. Peter Meinicke
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 15	

Georg-August-Universität Göttingen **Module M.Inf.1505: Models and Algorithms in Bioinformatics**	6 C 4 WLH
Learning outcome, core skills: After successful completion of the module, students • know the principles, paradigms, and challenges of models and algorithms for statistical data analysis in bioinformatics • understand and apply principles of scientific programming using concepts from statistics and linear algebra • can implement, train and evaluate probabilistic models for sequence analysis • know and apply algorithms for cluster analysis and visualization of multidimensional data • understand, recognize and solve numerical problems in the implementation of algorithms for model training and inference	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Models and Algorithms in Bioinformatics (Lecture, Exercise)	4 WLH
Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Participation in the exercises and successful completion of three exercise sheets. **Examination requirements:** Students should be able to understand, specify, use, implement and evaluate models and algorithms for biological data analysis and critically assess the limits of their applicability.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of molecular biology, algorithms and statistics; programming in Python.
Language: English	**Person responsible for module:** Dr. Peter Meinicke
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
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: 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 (PCHPC) (Block course) *Contents*: High-Performance Computing is the field that allows us to utilize the combined resources of 1000's of computers. Applications can utilize this compute power to solve research questions at the frontier of science but also solve important questions for our daily lives such as a weather forecast. *Teaching und learning methods:* 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.	4 WLH

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. *Remark:* If you like to prepare for the topic early, we can hand out a topic during the lecture free time before the term - just contact us.	
Examination: Presentation (15 min) and report (max 15 pages) for student project **Examination prerequisites:** Participation in the block seminar **Examination requirements:** Report (70%) and final presentation (30%)	6 C

Admission requirements: none	**Recommended previous knowledge:** • Programming experience in C++, C or Python • Parallel programming concepts • Linux
Language: English	**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.1830: FPV Quadcopter - Basics	6 C 4 WLH
Learning outcome, core skills: Nach Abschluss des Praktikums sollen die Teilnehmer*innen sind in der Lage sein, Quadcopter zu: • Entwerfen • Programmieren • Konstruieren • Tunen • Fliegen	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: FPV Quadcopter - Grundlagen (Internship) *Contents*: • Funktionsweise von Quadcoptern (Theorie und Praxis) • Konstruktion und Realisierung • Entwurf (auch mittels CAD Software) • Fertigung des Entwurfs (inkl. Löten, 3D-Druck etc.) • Programmierung des FC (flight controller) • PID Tuning und Ähnliches • Steuerung im ANGLE & ACRO Mode • Fliegen am Simulator und in der Realität auf einem anspruchsvollen Track Weitere Themen werden nach Bedarf der jeweiligen Quadcopterprojekte behandelt, etwa autonomes Fliegen, KI-gestützte Bildverarbeitung, long-range Flugtechnik, Löttechnik, spezielle 3D-Druck Techniken, Entwicklung Autopilot, betaflight Firmware etc. Weitere Details sowie ein Kursvideo finden Sie auf der Webseite zum Praktikum: www.gipplab.org/teaching.	4 WLH
Examination: Oral examination (approx. 20 minutes) **Examination requirements:** Die folgenden Themen werden in einer mündlichen Prüfung abgeprüft: • Funktionsweise von Quadcoptern (Theorie und Praxis) • Konstruktion und Realisierung • Entwurf (auch mittels CAD Software) • Fertigung des Entwurfs (inkl. Löten, 3D-Druck etc.) • Programmierung des FC (flight controller) • PID Tuning und Ähnliches • Steuerung im ANGLE & ACRO Mode • Fliegen am Simulator und in der Realität auf einem anspruchsvollen Track	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Bela Gipp

Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 8	

Additional notes and regulations:

Teilnehmer*innen können neben vorgegebenen Projekten auch ihre eigenen Ideen mit fachkundiger Unterstützung umsetzen. Die benötigten Bauteile, Geräte und Materialien werden vom Lehrstuhl bzw. der Universität gestellt.

Neben diesem Grundlagenkurs bietet der Lehrstuhl jeweils im Wintersemester auch einen Fortgeschrittenenkurs (M.Inf.1833) an.

Georg-August-Universität Göttingen Module M.Inf.1832: Lab Privacy and Security in Robotics and AI Systems	6 C 4 WLH
Learning outcome, core skills: On completion of the module, students should be able to: • Identify and understand existing privacy-preserving or security solutions in the area of robotics and/or artificial intelligence. • Design and implement a new approach to improve the investigated existing solutions, • Present their chosen approach in a written report justifying their design decisions and implementation choices as well as clearly document their implementation, • Give a presentation about their implemented approach.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Lab Privacy and Security in Robotics and AI Systems (Practical course)	4 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 and analyze the design space of their chosen topic, • They are able to make design decisions based on this analysis, • They are able to design and implement an approach improving the current state-of-the-art, • They are able to write a structured scientific report including their design decisions and the resulting solution by respecting the rules of good scientific practice, • They are able to present and critically discuss their implemented solution in a presentation, while respecting the given timeframe.	6 C

Admission requirements: none	**Recommended previous knowledge:** Backgrounds in security and privacy obtained in one or several of our offered lectures.
Language: English	**Person responsible for module:** Prof. Dr. Delphine Reinhardt
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.Inf.1833: FPV Quadcopter - Advanced**	6 C 4 WLH
Learning outcome, core skills: Nach Abschluss des Praktikums sollen die Teilnehmer sind in der Lage sein, Quadcopter auf fortgeschrittenem Niveau zu: • Entwerfen (per CAD) • Programmieren • Konstruieren • Tunen • Fliegen	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: FPV Quadcopter - Fortgeschrittenenkurs (Internship) *Contents*: Der Fokus des Fortgeschrittenenkurses liegt auf der Umsetzung selbst gewählter Projekte der Teilnehmer mit fachkundiger Unterstützung der Dozenten in den Themenbereichen: • Funktionsweise von Quadcoptern (Theorie und Praxis) • Konstruktion und Realisierung • Entwurf (auch mittels CAD-Software) • Fertigung des Entwurfs (inkl. Löten, 3D-Druck etc.) • Programmierung des FC (flight controller) • PID-Tuning und Ähnliches • Steuerung im ANGLE & ACRO Mode • Fliegen am Simulator und in der Realität auf einem anspruchsvollen Track Weitere Themen werden nach Bedarf der jeweiligen Quadcopterprojekte behandelt, etwa autonomes Fliegen, KI-gestützte Bildverarbeitung, long-range Flugtechnik, Löttechnik, spezielle 3D-Druck Techniken, Entwicklung Autopilot, betaflight Firmware etc. Weitere Details sowie ein Kursvideo finden Sie auf der Webseite zum Kurs: www.gipplab.org/teaching	4 WLH
Examination: Oral examination (approx. 20 minutes) **Examination requirements:** Die folgenden Themen werden in einer mündlichen Prüfung abgeprüft: • Funktionsweise von Quadcoptern (Theorie und Praxis) • Konstruktion und Realisierung • Entwurf (auch mittels CAD-Software) • Fertigung des Entwurfs (inkl. Löten, 3D-Druck etc.) • Programmierung des FC (flight controller) • PID-Tuning und Ähnliches • Steuerung im ANGLE & ACRO Mode • Fliegen am Simulator und in der Realität auf einem anspruchsvollen Track	6 C

Admission requirements:	**Recommended previous knowledge:**

Erfolgreiche Teilnahme am Grundlagenkurs (M.Inf.1830) im Sommersemester oder anderweitig erworbene gleichwertige Kenntnisse, welche in einem Fachgespräch mit Prof. Gipp nachzuweisen sind.	none
Language: German	**Person responsible for module:** Prof. Dr. Bela Gipp
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 8	

Additional notes and regulations:

Teilnehmer*innen können neben vorgegebenen Projekten auch ihre eigenen Ideen mit fachkundiger Unterstützung umsetzen. Die benötigten Bauteile, Geräte und Materialien werden vom Lehrstuhl bzw. der Universität gestellt.

Neben diesem Fortgeschrittenenkurs bietet der Lehrstuhl jeweils im Sommersemester auch einen Grundlagenkurs (M.Inf.1830) an.

Georg-August-Universität Göttingen Module M.Inf.1834: Extension High-Performance Computing (EHPC)	3 C 0,5 WLH
Learning outcome, core skills: Gain additional understanding of high-performance computing systems through an extended project work focused on developing and/or evaluating software for HPC systems. This module serves as an extension of our courses, in particular the Practical Course on High-Performance Computing (PCHPC) and Practical Course on HPC System Administration (HPCSA) such that students who want to spend extra effort on their project work for one of these courses can receive additional credits. In order to receive the extra credits, register to this module examination in FlexNow in addition to the regular module for the course and discuss this with the module organizer.	**Workload:** Attendance time: 7 h Self-study time: 83 h
Course: Practical Course on HPC (PCHPC) (Practical course) see M.Inf.1829	0,5 WLH
Course: High-Performance Computing System Administration (HPCSA) (Practical course) *Contents*: see M.Inf.1831	0,5 WLH
Examination: Additional 5 pages to the report of the extended module **Examination prerequisites:** Participation in the extended module **Examination requirements:** Similar to the extended module	3 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Julian Kunkel
Course frequency: each 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.1905: Advanced Topics in Language and Text Processing**	3 C 2 WLH

Learning outcome, core skills: A successful completion of the module enables the participants to: • describe the problem area that the course focusses on • name, illustrate and analyse the algorithms covered • evaluate and compare different analysis methods • select suitable algorithms for specific application scenarios	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced Topics in Language and Text Processing (Seminar) *Contents*: This course covers advanced topics in computational linguistics and natural language processing, for example processing creative language, processing non-standard language varieties, language processing for low-resource languages, argumentation mining, ethics and algorithmic bias, obtaining and incorporating world knowledge, multi-modal language processing, opinion mining, text generation etc. The students will learn about different sub-tasks for the given topic and become acquainted with state-of-the-art algorithms for tackling them. They will learn to understand how these algorithms work and will be able to critically assess them (i.e., what are the underlying assumptions an algorithm makes, in which circumstances they perform well or not so well, and how do they compare to other approaches). Students will also be enabled to understand and critically evaluate research papers in the field.	2 WLH
Examination: Presentation (max. 30 minutes) and term paper (max. 12 pages) **Examination prerequisites:** Participation in the exercise **Examination requirements:** The students can describe the problem area covered in the course, are able to illustrate and reflect on the current research literature and evaluate advantages and disadvantages for specific application scenarios of the methods covered in the course.	3 C

Admission requirements:	**Recommended previous knowledge:** Knowledge of basic language analysis tasks (tokenisation, part-of-speech tagging, syntactic parsing) and basic computational methods for performing them. Basic knowledge of probability theory (how to compute probabilities, conditional and joint probability, statistical in-/dependence, Bayes' theorem). Basic knowledge of linguistics (parts-of-speech, syntactic structure, word senses). The recommended knowledge can be obtained by taking an introductory course in computational linguistics/ natural language processing or working through a relevant reference book.

Language: English, German	**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: 25	

Georg-August-Universität Göttingen **Module M.Inf.1906: Computational Semantics and Discourse Processing**	6 C 4 WLH

Learning outcome, core skills: A successful completion of the module enables the participants to: • describe the problem area • name, describe and analyse the algorithms covered in the course • evaluate and compare different methods • select suitable algorithms for specific application scenarios	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Computational Semantics and Discourse Processing (Exercise, Seminar) *Contents*: This course covers selected topics in computational semantics and discourse processing, for example lexical semantics and word sense disambiguation, distributional semantics, compositionality and sentence semantics, semantic representations, semantic parsing, co-reference resolution, generating referring expressions, named entity recognition and disambiguation, modelling discourse coherence, temporal analysis, sentiment and emotion analysis, detecting discourse relations and discourse parsing, text generation etc. Students will learn basic semantic and pragmatic constructs and the challenges they pose to language processing. They will become aquainted with different approaches for analysing semantic and discourse phenomena and will be able to critically assess these.	4 WLH
Examination: Presentation (max. 30 minutes) and term paper (max. 12 pages) **Examination prerequisites:** Participation in the exercise **Examination requirements:** The students demonstrate knowledge of challenges and processing methods in the area of computational semantics and discourse processing and are able to explain and evaluate methods and theories in this area. They are able to: • describe the problem area • name, explain and analyse the algorithms covered in the course • evaluate and compare different methods • select suitable algorithms for specific application scenarios	6 C

Admission requirements: none	**Recommended previous knowledge:** Knowledge of basic language analysis tasks (tokenisation, part-of-speech tagging, syntactic parsing) and basic computational methods for performing them. The recommended knowledge can be obtained by taking an introductory course in computational linguistics/natural language processing or working through a relevant reference book.

Language: English, German	**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: 25	

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 Stephan Schlosser
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:	**Workload:**
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.	Attendance time: 56 h Self-study time: 124 h

Course: Advanced Statistical Learning for Data Science (Lecture)	2 WLH
Hastie, et al. Elements of Statistical Learning https://web.stanford.edu/~hastie/ElemStatLearn/ Bishop: Pattern Recognition and Machine Learning. https://cs.ugoe.de/prml	
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:** Jun.-Prof. Dr. Anne Christin Hauschild Prof. 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.2103: Statistical Network Inference and Analysis	6 C 4 WLH
Learning outcome, core skills: Students will • Learn the concepts of different network inference methods for observational data, such as probabilistic graphical models, e.g., Gaussian and Mixed Graphical Models or the Markov Random Field • Gain a solid understanding about regularization strategies to deal with large feature spaces, e.g., graphical lasso and covariance shrinkage • Learn state-of-the-art optimization strategies and use them to the implement networks inference methods • Acquire practical experience in network inference using diverse data types, e.g., demographic or biomedical data • Understand the concept of Directed Acyclic Graphs (DAGs) and learn to estimate lower bounds for causal effects from observational data • Understand and apply network inference methods for time-course data • Understand and apply analysis strategies for networks, e.g., community detection methods	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Statistical Network Inference and Analysis (Lecture, Exercise) Literature: Hastie, et al. Elements of Statistical Learning https://web.stanford.edu/~hastie/ElemStatLearn/	4 WLH
Examination: Written exam (90 min) or oral exam (30 min) **Examination prerequisites:** M.Inf.2103.Ex: At least 50% of homework exercises solved. **Examination requirements:** Knowledge about probabilistic graphical models, DAGs, Regularization strategies, Implementation strategies.	6 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge about statistical learning
Language: English	**Person responsible for module:** Prof. Dr. Michael Altenbuchinger
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 20	

Georg-August-Universität Göttingen **Module M.Inf.2201: Probabilistic Machine Learning**	9 C 6 WLH
Learning outcome, core skills: After successful completion of the module, students • know the principles, paradigms, and challenges of probabilistic reasoning • apply basis principles and tools to perform probabilistic reasoning • manipulate distributions and densities of random variables • apply different methods for inference in probabilistic models (direct solving, sampling, variational inference, Laplace approximation) • apply latent variable models for given problems • perform inference in various forms of Gaussian models using closure properties of the Gaussian family • use graphical models to describe and reason about multivariate distributions of random variables • apply and implement learning algorithms in probabilistic models • can choose from a toolbox of basic algorithms for probabilistic inference on given problems • can implement and debug probabilistic algorithms and inference techniques • apply state of the art deep probabilistic models such as variational autoencoders or normalizing flows	**Workload:** Attendance time: 84 h Self-study time: 186 h
Course: Probabilistic Machine Learning (Lecture)	4 WLH
Examination: Written exam (120 min.) or oral exam (approx. 30 min.) **Examination requirements:** • Ability to use principles and tools of probabilistic reasoning on given problems • Ability to extend and modify existing algorithms of probabilistic inference • Ability to diagnose problems in algorithms of probabilistic reasoning • Ability to mathematically derive results in probabilistic models • Ability to use graphical models to simplify problems of probabilistic reasoning • Knowledge of common models and algorithms of probabilistic inference (Gaussian, Bayesian logistic regression, autoencoders, normalizing flows, and others). • Knowledge of common sampling algorithms (importance sampling, MCMC)	9 C
Course: Probabilistic Machine Learning – Exercise (Exercise) Bonus % for the final exam can be gathered by successfully solving exercise sheets and defending them to a tutor.	2 WLH

Admission requirements: none	**Recommended previous knowledge:** • Basic knowledge of linear algebra • Basic knowledge of multivariate calculus • Python, in particular numpy • Basic knowledge of 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.2202: Deep Learning for Natural Language Processing**	6 C 4 WLH
Learning outcome, core skills: The course seeks to enable students to solve a wide range of applied problems in Natural Language Processing. After successfully completing the course, the participants should be able to: • Explain state-of-the-art methods to tackle NLP sub-problems, such as text representation, information extraction, text mining, language modeling, and similarity detection • Determine the conceptual requirements of specific NLP tasks • Assess the strengths and limitations of state-of-the-art NLP approaches • Devise solutions for complex, interdisciplinary NLP problems by implementing and adapting suitable algorithms and data structures • Evaluate NLP methods and systems quantitatively and qualitatively	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Lecture Deep Learning for Natural Language Processing (Lecture) *Contents*: The lecture will cover the following topics: Text representation • Words, sentences, paragraphs, documents • Text processing, regular expressions, tokenization, stemming, lemmatization • Bag-of-Words, weighting schemes (e.g., tf-idf), information retrieval • Minimum edit distance • Language models, N-grams, perplexity, information gain, smoothing • Word sense, lexical databases, distance measures Word embeddings and dense vector representations • Vector representation • Recap on NLP representations before 2013 • word2vec, GloVe, fastText • Paragraph-Vectors • Multi-Sense Embeddings • ELMo, USE Applications • Lexical databases, lexical semantics • Word sense disambiguation, semantic similarity • Part-of-speech tagging, parsing • Word similarity, word dissimilarity, distance measures • Text classification • Sentiment analysis / evaluation • Named entity recognition, information extraction, relation extraction • Questioning and answering, chatbots, dialog systems • Text summarization	2 WLH

• Machine translation • Fake news detection • Plagiarism / paraphrase detection • Math retrieval, MathML • Automatic detection of political opinions • Online harassment detection • Collaboration network analysis Please visit www.gipplab.org/teaching for details on this course.	
Examination: Written test (90 min.) or oral exam (approx. 20 min.) **Examination prerequisites:** Successful completion of the examination in the practical course component of this module. **Examination requirements:** • Knowledge of major NLP tasks, sub-tasks, and applications • Ability to explain state-of-the-art methods to address NLP tasks, such as text representation, information extraction, text mining, language modeling, and similarity detection • Ability to analyze the conceptual requirements of specific NLP tasks • Ability to compare the suitability of state-of-the-art NLP approaches for specific tasks • Ability to valuate NLP methods and systems quantitatively and qualitatively	2 C

Course: Practical Course Deep Learning for Natural Language Processing (Practical course) *Contents*: In the practical course, students work on applied research projects (teamwork is possible) that address complex NLP downstream tasks and subtasks, such as: • Word similarity • Document and Sentence classification • Named entity recognition • Question and answering system • Text summarization • Objective and subjective classification • Sentiment analysis • Part-of-speech tagging • Compositional knowledge entailment (entailment, contradiction, neutral) • Relation extraction and parsing • Machine translation • … Applications that participants can address in their projects include but are not limited to: • Plagiarism and paraphrase detection • Social media analysis • Fake news identification and classification • Spell checking • Detection of political opinions	2 WLH

• Identification of opinion polarity • Online harassment and bias identification systems • Collaboration network analysis Using the programming language Python and presenting the intermediate and final results of the projects is mandatory. Please visit www.gipplab.org/teaching for details on this course.	
Examination: Oral Presentation (approx. 20 minutes) **Examination prerequisites:** Successful completion of an applied research project including at least one intermediate milestone or presentation. **Examination requirements:** • Ability to analyze the conceptual requirements of specific NLP problems • Ability to determine the conceptual requirements of specific IR and NLP problems • Ability to compare the suitability of algorithms and data structures for specific NLP problems • Ability to devise solutions for complex, interdisciplinary NLP tasks by implementing and adapting suitable algorithms and data structures • Ability to evaluate NLP methods and systems quantitatively and qualitatively	4 C

Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of Python (e.g., branches, loops, object orientation) is required to complete the course. Experience with numpy, sckit-learn, pandas, and other libraries in the SciPy ecosystem is beneficial but not mandatory. For participants who are unfamiliar with Python, a fast-paced introduction into the essentials of the language will be provided.
Language: English	**Person responsible for module:** Prof. Dr. Bela Gipp
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Additional notes and regulations: This course provides a good foundation for a bachelor's or master's thesis in our group. Visit www.gipplab.org/students-corner/graduation-projects for our current theses proposals.

Georg-August-Universität Göttingen **Module M.Inf.2203: Interpretability and Bias of Machine Learning Models**	6 C 4 WLH

Learning outcome, core skills: After completion of this module, students can • explain the concepts underlying interpretability research and use the respective terminology appropriately • apply interpretability methods to better understand machine learning models • interpret and discuss the output of interpretability methods and their limitations • identify sources of bias for machine learning models and discuss their implications	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Interpretability and Bias of Machine Learning Models (Lecture)	2 WLH
Examination: Written exam (90 minutes) or oral exam (20 minutes) **Examination prerequisites:** Successful participation in exercise **Examination requirements:** Students need to achieve the learning goals	6 C

Course: Interpretability and Bias of Machine Learning Models - Exercise (Exercise)	2 WLH

Admission requirements: none	**Recommended previous knowledge:** Python programming skills **and** B.Inf.1236 or equivalent **or** B.Inf.1237 or equivalent **or** M.Inf.2202 or equivalent
Language: English	**Person responsible for module:** Prof. Dr. Lisa Beinborn
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.2204: Introduction to Graph Machine Learning**	5 C 2 WLH
Learning outcome, core skills: Upon completion of the module, students will • Understand the fundamental concepts and principles of graph machine learning • Understand the significance of graph data for machine learning as well as its challenges • Be able to apply various graph-based machine learning algorithms such as Message-Passing Graph Neural Networks (MPGNNs), Graph Kernels, and Graph Transformers • Learn to preprocess data, including handling of discrete numerical features such as the atomic number in molecular data • Implement graph machine learning algorithms such as message-passing GNNs and Graph Transformers based on machine learning libraries for graph learning • Be able to apply supervised and unsupervised learning strategies on graph data • Investigate practical data science problems using graph machine learning	**Workload:** Attendance time: 28 h Self-study time: 122 h
Course: Introduction to Graph Machine Learning (Lecture, Exercise) *Contents*: • Core Characteristics of Graph data • Methods: Graph Kernels, Message-Passing GNNs, Graph Transformer • Unsupervised node embeddings • Dense and sparse implementations of GNNs • Positional and Structural Embeddings • Machine learning workflow from dataset to prediction • Expressivity of GNNs and the Weisfeiler-Leman hierarchy	2 WLH
Examination: Oral exam (approx. 20 minutes) or written exam (90 minutes) **Examination prerequisites:** At least 50% of homework exercises solved and N-1 exercise sheets submitted. **Examination requirements:** Knowledge of basic Graph Learning paradigms with their advantages and disadvantages as well as possible application areas. Being able to implement those techniques.	5 C

Admission requirements: none	**Recommended previous knowledge:** General knowledge from Machine Learning and/or deep learning as well as basic python
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:**

Maximum number of students: 24	

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: Two Oral Presentations (approx. 20 minutes each), 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:** B.Inf.1236 and B.Inf.1237 or equivalent
Language: English	**Person responsible for module:** Prof. Dr. Alexander Ecker
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 4
Maximum number of students: 10	

Additional notes and regulations: For students who are writing their thesis in the Neural Data Science or Machine Learning Group.

Georg-August-Universität Göttingen Module M.Inf.2243: Selected Topics in Data Science	5 C 3 WLH
Learning outcome, core skills: After completing the module, students should be able to: • Investigate a specific topic in the Data Science field in depth • Identify research trends and existing solutions in the area to be investigated • Explain, compare, and discuss these solutions • Develop ideas to improve the current state of the art • Work independently in a pre-defined context • Gather, organize, read, analyze, and discuss scientific research papers • Write an academic paper • Give an academic presentation about their topic	**Workload:** Attendance time: 42 h Self-study time: 108 h
Course: Selected Topics in Data Science (Seminar) *Contents*: Please visit www.gipplab.org/teaching for details on this course.	3 WLH
Examination: Oral Presentation (approx. 20 minutes) **Examination prerequisites:** Completion of intermediate milestones **Examination requirements:** The students shall demonstrate their ability to: • Conduct literature research on a current Data Science topic • Identify, understand, and explain state-of-the-art approaches in the chosen area • Propose novel solutions to improve the current state-of-the-art methods • Either implement their ideas in software or write a structured scientific paper on their findings • Present and critically discuss their software project or scientific paper in a presentation	5 C

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

Additional notes and regulations: This course provides a good foundation for a bachelor's or master's thesis in our group. Visit www.gipplab.org/students-corner/graduation-projects for our current theses proposals.

Georg-August-Universität Göttingen Module M.Inf.2244: Seminar Deep Learning in Biology and Medicine	5 C 2 WLH
Learning outcome, core skills: Deep learning is already one of the most important data analysis methods in biological and medical research and is increasingly also used in clinical practice. Its applications range from protein folding and molecule design for drug discovery to gene sequence analysis to image analysis for microscopy data and medical imaging. As part of the seminar students will pick a specific application, learn how to perform literature research and prepare a presentation on the topic. After successful completion of the modul students will be able to • Appraise research in the area of deep learning in biology and medicine. • Compose a presentation covering their selected topic in depth. • Evaluate methods and findings of other researchers. • Understand and explain the methods and domain knowledge fundamental to their topic.	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Deep Learning in Biology and Medicine (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 deep learning applied in biology or medicine; written scientific report; oral presentation	5 C

Admission requirements: none	**Recommended previous knowledge:** B.Inf.1236; B.Inf.1237
Language: English	**Person responsible for module:** Prof. Dr. Constantin Pape
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 15	

Georg-August-Universität Göttingen Module M.Inf.2245: Journal club optimal transport for data analysis	5 C 2 WLH
Learning outcome, core skills: After successful completion of the module, students • have gained a deeper knowledge in specific topics of optimal transport based data analysis • 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 optimal transport for data analysis	2 WLH
Examination: Oral Presentation (approx. 30 minutes), not graded **Examination prerequisites:** Regular participation **Examination requirements:** Knowledge of current topics in optimal transport and data analysis; 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. Bernhard Schmitzer
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: 10	

Additional notes and regulations:
For students who are writing their thesis in the Optimal Transport Group.

Georg-August-Universität Göttingen Module M.Inf.2246: Advanced NLP	5 C 2 WLH
Learning outcome, core skills: After completion of this module, students can • Discuss state-of-the-art approaches for a selected field of advanced NLP using the appropriate terminology • Evaluate and interpret benchmark results for the selected task • Discuss the potential and limitations of existing methods and their societal implications Examples for selected fields are multilingual NLP, cognitive plausibility in NLP, interpretability, advanced language modeling	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Advanced NLP (Seminar)	2 WLH
Examination: Oral presentation (approx. 20 min.) and/or written report (2500 - 4500 words) **Examination prerequisites:** Successful participation in course **Examination requirements:** Students need to achieve the learning goals	5 C

Admission requirements: none	**Recommended previous knowledge:** M.Inf.2202 or equivalent
Language: English	**Person responsible for module:** Prof. Dr. Lisa Beinborn
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.2247: Data Science with Cognitive Signals	5 C 2 WLH
Learning outcome, core skills: After completion of this module, students can • describe the characteristics of different types of cognitive signals using appropriate terminology • explain different methods for integrating cognitive signals into data science models and discuss their strengths and weaknesses • apply processing methods on cognitive data and interpret the results	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Data Science with Cognitive Signals (Seminar)	2 WLH
Examination: Oral presentation (approx. 20 min.) and/or written report (2500 - 4500 words) **Examination prerequisites:** Successful participation in course **Examination requirements:** Students need to achieve the learning goals	5 C

Admission requirements: none	**Recommended previous knowledge:** Python programming skills
Language: English	**Person responsible for module:** Prof. Dr. Lisa Beinborn
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.2248: Seminar Math Information Retrieval	5 C 3 WLH
Learning outcome, core skills: After completing the module, students should be able to: • Investigate a specific topic in Math Information Retrieval in depth • Identify research trends and existing solutions in the area to be investigated • Explain, compare, and discuss these solutions • Develop ideas to improve the current state of the art • Work independently in a pre-defined context • Gather, organize, read, analyze, and discuss scientific research papers • Write an academic paper • Give an academic presentation about their topic	**Workload:** Attendance time: 42 h Self-study time: 108 h
Course: Seminar Math Information Retrieval (Seminar) *Contents*: Please visit www.gipplab.org/teaching for details on this course.	3 WLH
Examination: Oral Presentation (approx. 20 minutes) **Examination prerequisites:** Completion of intermediate milestones **Examination requirements:** The students shall demonstrate their ability to: • Conduct literature research on a current Math Information Retrieval topic • Identify, understand, and explain state-of-the-art approaches in the chosen area • Propose novel solutions to improve the current state-of-the-art methods • Either implement their ideas in software or write a structured scientific paper on their findings. • Present and critically discuss their software project or scientific paper in a presentation	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Dr. Bela Gipp
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Additional notes and regulations:
This course provides a good foundation for a bachelor's or master's thesis in our group. Visit www.gipplab.org/students-corner/graduation-projects for our current theses proposals.

Georg-August-Universität Göttingen **Module M.Inf.2249: Seminar Digital Humanities and Information Science**	5 C 3 WLH
Learning outcome, core skills: After completing the module, students should be able to: • Investigate a specific topic in the fields of Digital Humanities or Information Science in depth • Identify research trends and existing solutions in the area to be investigated • Explain, compare, and discuss these solutions • Develop ideas to improve the current state of the art • Work independently in a pre-defined context • Gather, organize, read, analyze, and discuss scientific research papers • Write an academic paper • Give an academic presentation about their topic	**Workload:** Attendance time: 42 h Self-study time: 108 h
Course: Seminar Digital Humanities and Information Science (Seminar) *Contents*: Please visit www.gipplab.org/teaching for details on this course.	3 WLH
Examination: Oral Presentation (approx. 20 minutes) **Examination prerequisites:** Completion of intermediate milestones **Examination requirements:** The students shall demonstrate their ability to: • Conduct literature research on a current topic in the fields of Digital Humanities or Information Science • Identify, understand, and explain state-of-the-art approaches in the chosen area • Propose novel solutions to improve the current state-of-the-art methods • Either implement their ideas in software or write a structured scientific paper on their findings. • Present and critically discuss their software project or scientific paper in a presentation	5 C

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

Additional notes and regulations: This course provides a good foundation for a bachelor's or master's thesis in our group. Visit www.gipplab.org/students-corner/graduation-projects for our current theses proposals.

Georg-August-Universität Göttingen **Module M.Inf.2250: Educational Language Technology**	5 C 2 WLH
Learning outcome, core skills: After completion of this module, students can • describe methods and application scenarios for educational language technology using appropriate terminology • Evaluate and interpret benchmark results for the selected task • Discuss the potential and limitations of existing methods and their societal implications Examples for educational technology are: essay scoring, simplification, exercise generation, learner modeling.	**Workload:** Attendance time: 28 h Self-study time: 122 h

Course: Educational Language Technology (Seminar)	2 WLH
Examination: Oral presentation (approx. 20 min.) and/or written report (2500 - 4500 words) **Examination prerequisites:** Successful participation in course **Examination requirements:** Students need to achieve the learning goals	5 C

Admission requirements: none	**Recommended previous knowledge:** Python programming skills, B.Inf.1248 or equivalent
Language: English	**Person responsible for module:** Prof. Dr. Lisa Beinborn
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.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; 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: Student’s Seminar (Colloquium)	1 WLH
Examination: Written report (max. 3000 words) and presentation (approx. 20 min.), not graded **Examination requirements:** Written and oral presentation of the background of the project and the methodology used, as well as a presentation and discussion of the results obtained. The report as well as the presentation should be realized in the style of a scientific paper / presentation 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
Maximum number of students: not limited	

Additional notes and regulations:
The duration of the lab rotation is 2-3 months full time.

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: Student's Seminar (Colloquium)	1 WLH
Examination: Written report (max. 3000 words) and presentation (approx. 20 min.), not graded **Examination requirements:** Written and oral presentation of the background of the project and the methodology used, as well as a presentation and discussion of the results obtained. The report as well as the presentation should be realized in the style of a scientific paper / presentation 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 2 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: 28 h Self-study time: 872 h
Course: Scientific Writing (Course)	1 WLH
Course: Student's Seminar (Colloquium)	1 WLH
Examination: Master's thesis **Examination prerequisites:** Students submit a research proposal as well as drafts of their thesis. Additionally, they review drafts by peers and revise their own drafts according to peer feedback. **Examination requirements:** By writing the Master's thesis, students demonstrate that they are able to work on a problem within the specified period of time using the methods of their 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: according to § 12 (1) PStO	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** 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: each summer semester	**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: 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: Linear Models and their Mathematical Foundations (Lecture) *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.	4 WLH
Course: Linear Models and their Mathematical Foundations (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:** Mathematical foundations of applied statistics
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: Nonparametric procedures (Lecture) Literature: 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: Nonparametric procedures (Exercise)	2 WLH
Examination: Klausur (90 Minuten) oder mündliche Prüfung (ca. 20 Minuten) **Examination prerequisites:** Achievement of at least 50% of the exercise points	6 C
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.	

Admission requirements: none	**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: 15	

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

Learning outcome, core skills:	**Workload:**
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.	Attendance time: 56 h Self-study time: 124 h

Course: Analysis of Longitudinal and Time-to-Event Data (Tutorial)	2 WLH
Course: Analysis of Longitudinal and Time-to-Event Data (Lecture)	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.

Only one of the modules M.MED.0020 and M.MED.0003 can be taken

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

Learning outcome, core skills:	**Workload:**

• 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
	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:** Dean of studies
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:** Dean of studies
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/Neuro-informatics	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.901: From Vision to Action	7 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: 154 h
Course: Biological Psychology – Neurosciences 1 (Lecture)	2 WLH
Course: Biological Psychology – Neurosciences 2 (Seminar)	2 WLH
Examination: Written examination (90 minutes)	7 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-BWL.0004: Financial Risk Management	6 C 4 WLH

Learning outcome, core skills: After a successful completion of the course students are able to: • understand and explain how risk management is related to other issues in corporate finance, • critically assess different motivations for corporate risk management, • understand and critically assess different risk measures and how they are applied in practice, • understand and explain how international risks can be managed and how the management of international risks is related to various economic parity conditions, • understand, analyze and critically apply measures and methods to manage interest rate risk, • understand, analyze and critically apply measures and methods to manage credit risk, • understand, analyze and critically apply hedging strategies for commodity price risk.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Financial Risk Management (Lecture) *Contents*: 1. Introduction 2. Risk Management: Motivation and Strategies 3. Managing Interest Rate Risk 4. Managing Credit Risk 5. Managing International Risks 6. Managing Commodity Price Risk Parts of the material covered by the lectures will be transmitted via recordings that students have to work through on their own. Parts of the contact hours during lectures will be used by the students to discuss open issues and to work on specific cases and applications of the main concepts.	2 WLH
Course: Financial Risk Management (Tutorial) *Contents*: In the accompanying practice sessions students deepen and broaden their knowledge from the lectures.	2 WLH
Examination: Written examination (60 minutes)	6 C

Examination requirements: • Demonstrate a profound knowledge of how risk management is related to other issues in corporate finance, • document an understanding of viable reasons for corporate risk management and how corporate risk management can create value, • demonstrate the ability to analyze and apply different risk measures,	

• show a profound understanding of methods and techniques used to manage international risks, interest rate risk, credit risk, and commodity price risk.	

Admission requirements: none	**Recommended previous knowledge:** M.WIWI-BWL.0001 Sustainable Finance
Language: English	**Person responsible for module:** Prof. Dr. Olaf Korn
Course frequency: each winter semester	**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-BWL.0010: Corporate Valuation**	6 C 4 WLH
Learning outcome, core skills: After successfully completing this course, the students are familiar with the valuation of firms depending on purpose and reason. The students should obtain knowledge of capital market-oriented Valuation and basics in capital market theory. The students should be able to design and perform a business valuation with and without personal taxes.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Corporate Valuation (Lecture) *Contents*: 1. Introduction to corporate valuation 2. Corporate valuation with perfect and complete capital markets 3. Capital Asset Pricing Model (CAPM) 4. Influence of the capital structure on market value and the costs capital without personal taxes 5. Consideration of personal taxes in corporate valuation 6. Forecasting future cash flows 7. Determination of the costs of capital, market value and plausibility check	2 WLH
Course: Corporate Valuation (Exercise) *Contents*: Within the associated tutorials, the students will deepen the contents of the lecture through sample calculations and case studies.	2 WLH
Examination: Written examination (90 minutes, 6 credits) or written examination (90 minutes, 5 credits and case study presentation approx. 20 minutes, 1 credit)	6 C
Examination requirements: Students are expected to prove their theoretical knowledge in the field of business valuation. Furthermore, students are expected to possess a comprehensive knowledge of approach, structure and procedure of business valuation depending on the financial structure under consideration of personal taxes if necessary. Moreover, the students have to apply this theoretical knowledge in case studies.	

Admission requirements: none	**Recommended previous knowledge:** M.WIWI-BWL.0085 Finance, Management Accounting and Sustainability Accounting
Language: German	**Person responsible for module:** Prof. Dr. Stefan Dierkes
Course frequency: each summer semester	**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-BWL.0153: Digital Marketing**	6 C 2 WLH

Learning outcome, core skills:	**Workload:**
After successfully completing this course, the students: • know core topics involved in the effective management of digital Marketing strategies, tactics, • know how to create a digital marketing strategy by analyzing the digital landscape, • know how to transform marketing strategies into digital marketing objectives and tactics, • know how to plan the implementation of strategies and tactics using state of the art digital marketing instruments: 1. digital outbound marketing (reaching out to and targeting consumers; e.g., display advertising) 2. digital inbound marketing (ensuring that consumers can find information about brands; e.g., search engine optimization), 3. social media marketing (motivating consumers to create and disseminate brand-related social media content; e.g., content marketing), 4. mobile marketing (connecting with customers through smartphones and other mobile devices). • know developments of latest digital marketing innovations, • know how to critically reflect on the concepts and methods of digital marketing management and how to apply them by completing case studies.	Attendance time: 28 h Self-study time: 152 h

Course: Digital Marketing (Lecture)	2 WLH
Contents: • Digital Marketing Strategy, • Digital Outbound Marketing, • Digital Inbound Marketing, • Social Media Marketing, • Mobile Marketing, • Outlook: Digital Marketing Innovations.	
Examination: Written examination (60 minutes)	4 C
Examination: Case study discussion in lecture	2 C

Examination requirements:	
• Theoretical and solution-oriented elaboration of digital marketing instruments, • application of digital marketing concepts, • one case assessment, presentation and discussion inclass (collaboration with other students in teams).	

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

English	Prof. Dr. Maik Hammerschmidt
Course frequency: each summer semester	**Duration:** 1 semester
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 3
Maximum number of students: 60	

Additional notes and regulations: Because of the case study discussion in lecture the maximum number of students is 60.

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	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: none	**Recommended previous knowledge:** Basic knowledge of statistical modelling using linear regression models

	M.WIWI-QMW.0002 Advanced Statistical Inference (Likelihood & Bayes)
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.

<table>
<tr><td>Georg-August-Universität Göttingen
Module M.WIWI-QMW.0002: Advanced Statistical Inference (Likelihood & Bayes)</td><td>6 C
4 WLH</td></tr>
</table>

<table>
<tr><td>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.</td><td>Workload:
Attendance time:
56 h
Self-study time:
124 h</td></tr>
</table>

<table>
<tr><td>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</td><td>2 WLH</td></tr>
<tr><td>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</td><td>2 WLH</td></tr>
<tr><td>Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes)</td><td>6 C</td></tr>
</table>

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<tr><td>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.</td><td></td></tr>
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Admission requirements: none	**Recommended previous knowledge:** Basic knowledge of mathematics and statistics
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.	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:** Basic knowledge in statistics 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 analyses.	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Multivariate Statistics (Lecture) *Contents*: Multivariate distributions and their properties (e.g., multivariate normal distribution), copulas, classification methods, principal component analysis, cluster analysis.	2 WLH
Course: Multivariate Statistics (Exercise) *Contents*: In the accompanying exercise, students deepen and expand the knowledge and skills acquired in the lecture.	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 25 minutes)	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:** Basic knowledge of statistical modelling using linear regression models M.WIWI-QMW.0002 Advanced Statistical Inference (Likelihood & Bayes)
Language: English	**Person responsible for module:** 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	

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	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:** Basic knowledgin in 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:	**Recommended semester:**

twice	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.	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:** Basic knowledge of statistical modelling using linear regression models M.WIWI-QMW.0002 Advanced Statistical Inference (Likelihood & Bayes)
Language: English	**Person responsible for module:** 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 Linear Models and their Mathematical Foundations M.WIWI-QMW.0021 Introduction to Statistical Programming
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) **Examination prerequisites:** Regular attendance	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 M.WIWI-QMW.0041: Stochastic Processes**	6 C 4 WLH

Learning outcome, core skills: Upon completion of the module, the students have acquired the following competencies: • familiarity with concepts of different stochastic processes, • experience in the practical analysis of modeling data via stochastic processes, • interpretation of the results of such models.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Stochastic Processes (Lecture) *Contents*: Stochastic processes in discrete and continuous time such as Wiener processes, Poisson processes, Markov chains, Markov processes.	2 WLH
Course: Stochastic Processes (Exercise) *Contents*: In the accompanying exercise, students deepen and expand the knowledge and skills acquired in the lecture.	2 WLH
Examination: Written examination (90 minutes) or oral examination (approx. 25 minutes)	6 C

Examination requirements: The students show in the exam that they have learned to perform the steps and calculations involved in analyses of stochastic processes. 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:** Basic knowledge of statistical modelling, M.WIWI-QMW.0002 Advanced Statistical Inference (Likelihood & Bayes)
Language: English	**Person responsible for module:** Prof. Dr. Elisabeth Bergherr
Course frequency: once a year	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 3

Georg-August-Universität Göttingen **Module M.WIWI-WIN.0002: Integrated Application Systems**	6 C 2 WLH
Learning outcome, core skills: After successful participation in the module, students are able to: • describe and explain the theoretical foundations in connection with integrated theory, • distinguish essential aspects of horizontal and vertical integration and to explain the implementation in integration concepts, • explain and analyze the most important application system types, • explain and evaluate integrated information processing in various economic applications using practical examples, as well as apply and transfer them to related situations, • analyze and critically reflect selected current trends in the field of integrated information processing, • work on tasks in teamwork with the help of learned communication and organizational skills.	**Workload:** Attendance time: 28 h Self-study time: 152 h
Course: Integrated Application Systems (Lecture) *Contents*: • Presentation of the basics of application systems and integration, IT governance, • presentation of objectives and limits of integration as well as different application system architectures and underlying integration concepts, • presentation of electronic data exchange and introduction to Semantic Web and ontologies, • presentation of integrated application systems in the context of CRM, enterprise portals, integrated debtors management, supply chain management, efficient consumer response, integrated production, payment traffic systems, travel distribution systems, and integrated systems in the media industry.	2 WLH
Examination: Written examination (120 minutes) **Examination prerequisites:** Three successfully certified works on case studies.	
Examination requirements: In the exam, students will prove that they: • are able to explain and assess theories and concepts for the integration of application systems, • are able to analyze complex tasks within the framework of integrated information processing in a short period of time and are able to identify both challenges and solution, • are able to transfer lecture-based approaches to comparable problems.	

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

German	Prof. Dr. Matthias Schumann
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 2
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module M.WIWI-WIN.0003: Information Management**	6 C 4 WLH

Learning outcome, core skills: Students: • know the roles and tasks of IT organization within organizations as well as respective evolutions over the last years, • know intra-, extra- and interorganizational requirements for modern information management and can point out common shortcomings in practice, • have detailed knowledge of the model, principles, and objectives of integrated information management with its domains, • can reflect the concepts and tools of integrated information management, and apply it to a problem including written documentation, • understand scientific articles concerning information management and are able to discuss them, • independently and adequately work on scientific research questions related to information management using methods relevant in Business Information Systems.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Information Management (Lecture) *Contents*: • information management: introduction & foundations • IT sales management • IT production management • IT procurement management • strategic IT management • digital business management: introduction & foundations • digital resources • digital demand • digital business models • digital business ecosystems • selected application domains of information systems: smart mobility, digital health, Industry 4.0 • highlights / Q&A	2 WLH
Course: Information Management (Exercise)	2 WLH
Examination: Written Examination (120 minutes) or oral examination (individual or group examination; approx. 15 minutes) **Examination prerequisites:** Attending guest lectures offered as part of this module is mandatory and a prerequisite for participation in the examination. Not attending these lectures / not fulfilling examination prerequisites can lead to exclusion from the examination.	6 C

Examination requirements:	

In this module's examination, students demonstrate that they are able to apply their knowledge in a solution-driven way on the base of case studies, in addition to the reproduction of foundations and concepts of integrated information management. This includes the transfer of their knowledge on information management to use cases and the application of tools stemming from Business Information Systems in particular. Moreover, students are able to critically appreciate the proposed approach and to adapt it during the application to a given problem.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: German	**Person responsible for module:** Prof. Dr. Lutz Maria Kolbe
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 2
Maximum number of students: not limited	

Georg-August-Universität Göttingen Module M.WIWI-WIN.0033: Digital Platforms	6 C 4 WLH

Learning outcome, core skills: The objective of this course is to convey a basic understanding of the paradigms and intricacies of digital platforms and platform business models. Students will be able to apply this knowledge to critically analyze and evaluate digital platform approaches. Moreover, it equips them with the necessary theories and models to develop strategies for digital platforms and to assess current issues in the topic area quantitatively and qualitatively. In the exercise part of the course, students apply their acquired knowledge and thereby advance their problem solving skills.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Digital Platforms (Lecture) *Contents*: Digital platforms are becoming increasingly important. Two-sided markets complement, extend, and replace traditional modes of transacting in many domains. Examples include B2B and B2C e-commerce platforms, platforms for interorganizational integration, resale and auction platforms, crowd work, delivery services as well as P2P services, such as short-term accommodation sharing and ride sharing markets. Importantly, the platform principle bears several particularities which will be examined in this course. Central to the design and operation of digital platforms and associated business models is the existence of network effects, different user types and motives, and the paramount importance of reputation systems and management. Case studies and guest lectures can complement the course. Topics covered in this course include: • The economics of platforms and multi-sided markets • Platform business models • Strategies for starting digital platforms • Competition among and within digital platforms • Platform governance • User motives, types, and representations on digital platforms • Pricing strategies for and on digital platforms • Trust and reputation systems • Network analysis	2 WLH
Course: Digital Platforms (Exercise) *Contents*: Within the accompanying exercise, the students deepen and extend the knowledge and skills acquired in the lecture by means of application tasks and examples.	2 WLH
Examination: Written examination (60 minutes)	6 C

Examination requirements: • Demonstration of in-depth knowledge on the paradigms and intricacies of digital platforms and platform business models, • evidence of the ability to quantitively and qualitatively address current issues on digital platforms.	

Admission requirements: none	**Recommended previous knowledge:** basic Excel skills
Language: English	**Person responsible for module:** Prof. Dr. Manuel Trenz
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 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	