Modulverzeichnis

zu der Prüfungs- und Studienordnung für den konsekutiven Master-Studiengang "Mathematik" (Amtliche Mitteilungen I Nr. 14/2013 S. 313, zuletzt geaendert durch Amtliche Mitteilungen I Nr. 46/2018 S. 1050)

Module

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Übersicht nach Modulgruppen

I. Study tracks in the Master's Degree programme in Mathematics (M.Sc.)

In the Master's Degree programme in Mathematics, one of the following study tracks has to be chosen, whereas modules with a total of at least 90 C have to be completed successfully in accordance with the following regulations. The regulations for the modules that can be chosen within the scope of a study focus can be found in No. II "Elective courses in Mathematics (graduate studies)".

Im Master-Studiengang „Mathematik" ist eines der nachfolgenden Studienprofile zu wählen, wobei nach Maßgabe der folgenden Bestimmungen Module im Umfang von wenigstens 90 C erfolgreich zu absolvieren sind. Die im Rahmen eines Schwerpunktes wählbaren Module sind unter "II. Elective courses in Mathematics (graduate studies)" geregelt.

1. Study track F "Research-oriented - general"

In the study track F "Research-oriented - general" modules have to be completed successfully according to the regulations below.

Im Studienprofil F „Forschungsorientiert - allgemein" sind Module nach Maßgabe der nachstehenden Bestimmungen erfolgreich zu absolvieren.

a. Elective compulsory modules in Mathematics (60 C)

In the study track F, elective compulsory modules in the subject mathematics with a total of at least 60 C have to be completed successfully according to the following regulations:

Im Studienprofil F müssen Wahlpflichtmodule im Fach Mathematik im Umfang von insgesamt mindestens 60 C nach Maßgabe der folgenden Bestimmungen erfolgreich absolviert werden:

i) In the study foci SP 1 or SP 2, modules with a total of at least 12 C have to be completed successfully, thereof at least a seminar module or an advanced seminar module with at least 3C (M.Mat.481*, M.Mat.482*, M.Mat.491*, M.Mat.492*). If the Master's thesis is in one out of these two study foci, a total of at least 6 C of the modules out of the other study focus have to be completed successfully.

Aus den Schwerpunkten SP 1 oder SP 2 müssen Module im Umfang von insgesamt wenigstens 12 C erfolgreich absolviert werden, davon mindestens ein Seminar- oder Oberseminarmodul (M.Mat.481*, M.Mat.482*, M.Mat.491*, M.Mat.492*) im Umfang von wenigstens 3 C; ist einer dieser beiden Schwerpunkte der Studienschwerpunkt der Masterarbeit, so müssen mindestens 6 C aus Modulen des anderen Schwerpunkts erworben werden.

ii) In the study foci SP 3 or SP 4, modules with a total of at least 12 C have to be completed successfully, thereof at least a seminar module or an advanced seminar module with at least 3C (M.Mat.483*, M.Mat.484*, M.Mat.493*, M.Mat.494*). If the Master's thesis is in one out of these two study foci, a total of at least 6 C of the modules out of the other study focus have to be completed successfully.

Aus den Schwerpunkten SP 3 oder SP 4 müssen Module im Umfang von insgesamt wenigstens 12 C erfolgreich absolviert werden, davon mindestens ein Seminar- oder Oberseminarmodul (M.Mat.483*, M.Mat.484*, M.Mat.493*, M.Mat.494*) im Umfang von wenigstens 3 C; ist einer dieser beiden Schwerpunkte der Studienschwerpunkt der Masterarbeit, so müssen mindestens 6 C aus Modulen des anderen Schwerpunkts erworben werden.

iii) Further modules can be chosen freely out of the modules offered in all four mathematical study foci.

Darüber hinaus kann frei aus den angebotenen Modulen aller vier mathematischen Studienschwerpunkte gewählt werden.

b. Elective compulsory modules in the minor subject (18 C)

In the study track F, modules with at total of at least 18 C have to be completed successfully in one out of the following minor subjects: Astrophysics, Business Administration, Chemistry, Computer Science, Philosophy, Physics, Economics. The regulations for the modules to choose from in each case can be found in No.III "Minor subjects in the graduate programme in Mathematics".

Im Studienprofil F sind Module im Gesamtumfang von wenigstens 18 C in einem der folgenden Nebenfächer erfolgreich zu absolvieren: Astrophysik, Betriebswirtschaftslehre, Chemie, Informatik, Philosophie, Physik, Volkswirtschaftslehre. Die jeweils wählbaren Module sind in "III. Minor subjects in the graduate programme in Mathematics" geregelt.

c. Elective modules in the key competencies area (12 C)

Modules with a total of at least 12 C have to be completed successfully, among them one out of the key competencies modules offered by the Unit Mathematics, according to the regulations in No. IV. "Key competencies in the graduate programme in Mathematics". The remaining modules can be chosen freely from the cross-faculty key competencies offer. The choice of other modules (alternative modules) is only possible with the approval of the dean of students of the faculty that offers the module. The choice of an alternative module has to be reported to the Study Office Mathematics in advance.

Es sind Module im Gesamtumfang von wenigstens 12 C erfolgreich zu absolvieren, darunter eines der Schlüsselkompetenzmodule aus dem Angebot der Lehreinheit Mathematik nach "IV. Key competencies in the graduate programme in Mathematics". Die übrigen Module können frei aus dem universitätsweiten Schlüsselkompetenzangebot gewählt werden. Die Belegung anderer Module (Alternativmodule) ist mit Zustimmung der Studiendekanin oder des Studiendekans der Fakultät, die das Modul anbietet, ebenfalls möglich. Die Belegung eines Alternativmoduls ist dem Studienbüro vorab anzuzeigen.

2. Study track W "Economathematics"

In the research-oriented study track W "Economathematics" modules below have to be completed successfully according to the regulations.

Im forschungsorientierten Studienprofil W "Wirtschaftsmathematik" sind Module nach Maßgabe der nachstehenden Bestimmungen erfolgreich zu absolvieren.

a. Elective compulsory modules in the subject-specific area (60 C)

In the study track W, elective compulsory modules in the subject Mathematics with a total of at least 60 C have to be completed successfully according to the following regulations:

Im Studienprofil W müssen Wahlpflichtmodule im Fach Mathematik im Umfang von insgesamt mindestens 60 C nach Maßgabe der folgenden Bestimmungen erfolgreich absolviert werden:

aa. Elective compulsory modules in SP 3

In the study focus SP 3, modules with a total of at least 18 C have to be completed successfully, thereof the following module:

Es müssen Module aus SP 3 im Umfang von insgesamt wenigstens 18 C erfolgreich absolviert werden, darunter das folgende Modul:

bb. Elective compulsory modules in SP 4

In the study focus SP 4, modules with a total of at least 18 C have to be completed successfully, thereof the following module:

Es müssen Module aus SP 4 im Umfang von insgesamt wenigstens 18 C erfolgreich absolviert werden, darunter das folgende Modul:

cc. (Advanced) seminar in the study focus

In the study focus of the Master's thesis, a seminar module or an advanced seminar module with 3 C (M.Mat.483*, M.Mat.484*, M.Mat.493*, M.Mat.494*) has to be completed successfully. Only the study foci SP 3 or SP 4 are permitted as study focus of the Master's thesis.

Im Studienschwerpunkt der Masterarbeit muss ein Seminar- oder Oberseminarmodul im Umfang von 3 C erfolgreich absolviert werden. Als Schwerpunkt der Masterarbeit sind nur die Schwerpunkte SP 3 oder SP 4 zugelassen.

dd. Practical Course

One out of the following practical course modules with 10 C has to be completed successfully:

Eines der folgenden Praktikumsmodule im Umfang von 10 C muss erfolgreich absolviert werden:

ee. Computer science

In the area No. III)4) "Computer science", one module with 5 C has to be completed successfully, the following two modules are recommended.

Es muss ein Modul aus dem Bereich "III)4) Informatik" im Umfang von 5 C erfolgreich absolviert werden. Empfohlen werden.

ff. Elective modules

Furthermore, in the study foci or in one of the minor subjects Business Administration, Economics or Business Law, modules with a total of at least 6 C have to be completed successfully.

Ferner müssen Module im Gesamtumfang von wenigstens 6 C aus einem der Schwerpunkte oder aus den Nebenfächern Betriebswirtschaftslehre, Volkswirtschaftslehre oder Wirtschaftsrecht erfolgreich absolviert werden.

b. Elective compulsory modules in the minor subject (14 C)

In the study track W, out of the following minor subjects modules with a total of at least 14 C have to be completed successfully: Business Administration, Economics or Business law. The regulations for the modules that can be chosen can be found in No.III. "Minor subjects in the graduate programme in Mathematics".

Im Studienprofil W sind Module im Gesamtumfang von mindestens 14 C aus den folgenden Nebenfächern erfolgreich zu absolvieren: Betriebswirtschaftslehre, Volkswirtschaftslehre oder Wirtschaftsrecht. Die wählbaren Module sind in "III. Minor subjects in the graduate programme in Mathematics" geregelt.

c. Elective modules in the key competencies area (16 C)

Modules with a total of at least 16 C have to be completed successfully according to the following regulations:

Es sind Module im Gesamtumfang von wenigstens 16 C nach Maßgabe der folgenden Bestimmungen erfolgreich zu absolvieren.

aa. Internship

In the study track W, the following module with 10 C has to be completed successfully:

Im Studienprofil W ist das folgende Modul im Umfang von 10 C erfolgreich zu absolvieren:

bb. Further key competencies modules

Furthermore, modules can be chosen freely from the cross-faculty key competencies offer. The choice of other modules (alternative modules) is only possible with the approval of the dean of students of the faculty that offers the module. The choice of an alternative module has to be reported to the Study Office Mathematics in advance. It is recommended to choose one of the following modules:

Ferner kann frei aus dem universitätsweiten Schlüsselkompetenzangebot gewählt werden. Die Belegung anderer Module (Alternativmodule) ist mit Zustimmung der Studiendekanin oder des Studiendekans der Fakultät, die das Modul anbietet, ebenfalls möglich. Die Belegung eines Alternativmoduls ist dem Studienbüro vorab anzuzeigen. Es wird empfohlen, eines der folgenden Module zu absolvieren:

3. Study track Phy "Physics"

In the research-oriented study track Phy "Physics", modules below have to be completed successfully according to the regulations.

Im forschungsorientierten Studienprofil Phy "Physik" sind Module nach Maßgabe der nachstehenden Bestimmungen erfolgreich zu absolvieren.

a. Elective compulsory modules in Mathematics (60 C)

In the study track Phy, elective compulsory modules covering a total of at least 60 C have to be completed successfully according to the following regulations:

Im Studienprofil Phy müssen Wahlpflichtmodule im Umfang von insgesamt mindestens 60 C nach Maßgabe der folgenden Bestimmungen erfolgreich absolviert werden.

i) In the study foci SP 2 or SP 4, ective compulsory modules with a total of at least 12 C have to be completed successfully, thereof at least a seminar module or an advanced seminar module with at least 3 C (M.Mat.483*, M.Mat.484*, M.Mat.493*, M.Mat.494*).

Es müssen Wahlpflichtmodule aus den Schwerpunkten SP 3 oder SP 4 im Gesamtumfang von wenigstens 12 C erfolgreich absolviert werden, davon mindestens ein Seminar- oder Oberseminarmodul im Umfang von wenigstens 3 C.

ii) In the cycles "Mathematical Methods in Physics", "Analysis of Partial Differential Equations", "Differential Geometry", "Algebraic Topology", "Non-commutative Geometry" and "Groups, Geometry and Dynamical Systems", modules with a total of at least 12 C have to be completed successfully, thereof at least a seminar module or an advanced seminar module with at least 3C.

Es müssen Module im Gesamtumfang von mindestens 12 C aus den Zyklen Mathematische Methoden der Physik, Analysis partieller Differenzialgleichungen, Differenzialgeometrie, Algebraische Topologie, Nichtkommutative Geometrie sowie Gruppen, Geometrie und Dynamische Systeme erfolgreich absolviert werden, davon mindestens ein Seminar- oder Oberseminarmodul im Umfang von wenigstens 3 C.

iii) Further moduls can be chosen freely out the modules offered in all four mathematical study foci SP1-4. Additionally, modules in the section No. III.6. "Physics" can be chosen freely, however this option is restricted to modules with a total of at most 12 C.

Ferner kann frei aus den angebotenen Modulen aller vier mathematischen Studienschwerpunkte gewählt werden. Weiterhin können Module im Gesamtumfang von maximal 12 C aus dem Bereich "III.6. Physics" frei gewählt werden.

b. Elective compulsory modules in the minor subject (18 C)

In the study track Phy, in the minor subject "Physics", modules with a total of at least 18 C have to be completed successfully. The regulations for the modules that can be chosen can be found in No.III "Minor subjects in the graduate programme in Mathematics".

Im Studienprofil Phy sind Module im Gesamtumfang von mindestens 18 C im Nebenfach Physik erfolgreich zu absolvieren. Die jeweils wählbaren Module sind in "III. Minor subjects in the graduate programme in Mathematics" geregelt.

c. Elective modules of the key competencies area (12 C)

At least one key competencies module out of the offer of the Faculty of Physics or out of the offer of the Unit Mathematics has to be completed successfully. Furthermore, modules can be chosen freely from the cross-faculty key competencies offer. The choice of other modules (alternative modules) is only possible with the approval of the dean of students of the faculty that offers the module. The choice of an alternative module has to be reported to the Study Office Mathematics in advance.

Es ist ein Schlüsselkompetenzmodul aus dem Angebot der Fakultät für Physik oder eines aus dem Angebot der Lehreinheit Mathematik erfolgreich zu absolvieren. Ferner können frei Module aus dem universitätsweiten Schlüsselkompetenzangebot gewählt werden. Die Belegung anderer Module (Alternativmodule) ist mit Zustimmung der Studiendekanin oder des Studiendekans der Fakultät, die das Modul anbietet, ebenfalls möglich. Die Belegung eines Alternativmoduls ist dem Studienbüro vorab anzuzeigen.

4. Study track MDS "Mathematical Data Science"

In the study track MDS "Mathematical Data Science" modules have to be completed successfully according to the regulations below.

Im forschungsorientierten Studienprofil MDS "Mathematical Data Science" sind Module nach Maßgabe der nachstehenden Bestimmungen erfolgreich zu absolvieren.

a. Elective compulsory modules in Mathematics (60 C)

In the study track MDS, elective compulsory modules in the subject mathematics with a total of at least 60 C have to be completed successfully according to the following regulations:

Im Studienprofil MDS müssen Wahlpflichtmodule im Umfang von insgesamt mindestens 60 C nach Maßgabe der folgenden Bestimmungen erfolgreich absolviert werden.

aa. Elective compulsory modules in SP 3

In the cycles listed below, modules with a total of at least 12 C have to be completed successfully, thereof at least a seminar module or an advanced seminar module with at least 3C.

Es müssen Module im Gesamtumfang von mindestens 12 C, davon mindestens ein Seminar- oder Oberseminarmodul im Umfang von wenigstens 3 C, aus den folgenden Zyklen absolviert werden.

- Optimisation
- Variational analysis
- Image and geometry processing
- Scientific computing / applied mathematics

bb. Elective compulsory modules in SP 4

In the cycles listed below, modules with a total of at least 12 C have to be completed successfully, thereof at least a seminar module or an advanced seminar module with at least 3C.

Es müssen Module im Gesamtumfang von mindestens 12 C, davon mindestens ein Seminar- oder Oberseminarmodul im Umfang von wenigstens 3 C, aus den folgenden Zyklen absolviert werden.

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

cc. (Advanced) seminar in the study focus

In the study focus of the Master's thesis, a seminar module or an advanced seminar module with 3 C (M.Mat.483*, M.Mat.484*, M.Mat.493*, M.Mat.494*) has to be completed successfully. Only the study foci SP 3 or SP 4 are permitted as study focus of the Master's thesis.

Im Studienschwerpunkt der Masterarbeit muss ein Seminar- oder Oberseminarmodul im Umfang von 3 C erfolgreich absolviert werden. Als Schwerpunkt der Masterarbeit sind nur die Schwerpunkte SP 3 oder SP 4 zugelassen.

dd. Practical course

One out of the following practical course modules with 10 C has to be completed successfully:

Eines der folgenden Praktikumsmodule im Umfang von 10 C muss erfolgreich absolviert werden:

ee. Computer science

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In the area "Computer science", one out of the following modules has to be completed successfully.

Es muss eines der folgenden Module erfolgreich absolviert werden.

ff. Elective modules

In order to achieve 60 C, modules out of the four study foci in Mathematics can be added In addition, modules with a total of at most 12 C can be chosen in the subject "Computer science" as listed in No.III.4 "Computer Science". However, those listed in No.I.4.a.ee) "Computer Science" are recommended.

Zum Auffüllen auf 60 C kann frei aus den angebotenen Modulen aller vier mathematischen Studienschwerpunkte gewählt werden. Weiterhin können Module im Gesamtumfang von maximal 12 C aus dem Bereich III.4 "Computer Science" frei gewählt werden, empfohlen werden die im Abschnitt .I.4.a.ee) "Computer Science" gelisteten Module.

b. Elective compulsory modules in the minor subject (18 C)

In the study track MDS, in the minor subject "Computer science" modules with a total of at least 18 C have to be completed successfully. The regulations can be found in No.III.4) "Computer science". However, those listed in No.I.4.a.ee) "Computer Science" are recommended.

Im Studienprofil MDS sind Module im Gesamtumfang von mindestens 18 C im Nebenfach Informatik erfolgreich zu absolvieren. Die wählbaren Module sind in Nr. III.4) "Computer science" geregelt, empfohlen werden die im Abschnitt I.4.a.ee) "Computer Science" gelisteten Module.

c. Elective modules in the key competencies area (12 C)

One out of the key competencies modules offered by the Unit Mathematics has to be completed successfully. Furthermore, modules can be chosen freely from the cross-faculty key competencies offer. The choice of other modules (alternative modules) is only possible with the approval of the dean of students of the faculty that offers the module. The choice of an alternative module has to be reported to the Study Office Mathematics in advance. It is recommended to choose one of the following modules.

Es ist ein Schlüsselkompetenzmodul aus dem Angebot der Fakultät für Mathematik und Informatik erfolgreich zu absolvieren. Ferner können frei Module aus dem universitätsweiten Schlüsselkompetenzangebot gewählt werden. Die Belegung anderer Module (Alternativmodule) ist mit Zustimmung der Studiendekanin oder des Studiendekans der Fakultät, die das Modul anbietet, ebenfalls möglich. Die Belegung eines Alternativmoduls ist dem Studienbüro Mathematik vorab anzuzeigen.

II. Elective courses in Mathematics (graduate studies)

1. Elective compulsory modules in study focus SP 1 "Analysis, geometry, topology"

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2. Elective compulsory modules in study focus SP 2 "Algebra, geometry, number theory"

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3. Elective compulsory modules in study focus SP 3 "Numerical and applied mathematics"

4. Elective compulsory modules in study focus SP 4 "Mathematical stochastics"

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III. Minor subjects in the graduate programme in Mathematics

1. Astrophysics

In "Astrophysics" as a minor subject the following module has to be completed successfully. Furthermore, all modules with module number B.Phy.55** and M.Phy.55** may be chosen.

Im Nebenfach "Astrophysik" ist folgendes Modul erfolgreich zu absolvieren. Weiterhin stehen alle Module mit Modulnummern B.phy.55** und M.Phy.55** zur Auswahl.

2. Business Administration

In "Business Administration" as a minor subject the following modules may be chosen.

Im Nebenfach "Betriebswirtschaftslehre" stehen folgende Module zur Auswahl:

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3. Chemistry

In "Chemistry" as a minor subject the following module may be chosen. Furthermore all modules in Chemistry out of the graduate programm in Chemistry (module number M.Che.****) can be chosen. Selection of modules out of the undergraduate programme in Chemistry may be selected provided approval through the dean of studies of the Faculty of Chemistry. In this case the Study Office Mathematics must be informed beforehand.

Im Nebenfach "Chemie" stehen folgende Module zur Auswahl. Darüber hinaus können alle Chemie-Module aus dem Master-Studiengang "Chemie" (Modul-Nummern M.Che.****) gewählt werden. Die Belegung von Chemie-Modulen aus dem Bachelor-Studiengang "Chemie" ist mit Zustimmung durch die Studiendekanin oder den Studiendekan der Fakultät für Chemie zulässig. Die Belegung eines solchen Moduls ist dem Studienbüro vorab anzuzeigen.

4. Computer Science

In "Computer Science" as a minor subject all the modules with module number B.Inf.**** or M.Inf.**** can be chosen with the exception of the following modules.

Im Nebenfach „Informatik" stehen alle Module mit den Modul-Nummern B.Inf.**** und M.Inf.**** zur Auswahl. Davon abweichend können folgende Module nicht eingebracht werden.

- B.Inf.1101: Informatik I
- B.Inf.1102: Informatik II

5. Philosophy

In "Philosophy" as a minor subject the following modules can be chosen; for at least one of the selected modules a term paper has to be prepared.

Im Nebenfach "Philosophie" stehen folgende Module zur Auswahl; in einem der gewählten Module muss eine Hausarbeit angefertigt werden:

6. Physics

In "Physics" as a minor subject all modules with module number B.Phy.**** or M.Phy.*** can be chosen, with the <u>exception</u> of the following module:

Im Nebenfach "Physik" stehen alle Module mit den Modul-Nummer B.Phy.**** oder M.Phy.**** zur Auswahl. Davon abweichend kann folgendes Modul <u>nicht</u> absolviert werden:

• B.Phy.1301 "Rechenmethoden der Physik"

7. Economics

In "Economics" as a minor subject the following modules can be chosen:

Im Nebenfach "Volkswirtschaftslehre" stehen folgende Module zur Auswahl:

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8. Business Law (Nebenfach)

In the study track Economathematics, in "Business Law" as a minor subject the module below as well as modules out of the core curriculum of the Bachelor's programme with two subjects, subject "Law", can be chosen, provided the required previous knowledge in each case is given and with the exception of the modules of the basic courses in Civil Law (module numbers S.RW.011*). It is especially recommended to choose modules in one of the module packets in the practice-oriented track of the 2FBA undergraduate programme as well as to participate in a study advisory service.

Im Studienprofil W können im Nebenfach "Wirtschaftsrecht" mit Ausnahme der Grundkurs-Module im Bürgerlichen Recht (Modulnummern S.RW.011*) das nachstehende Modul sowie alle Module aus dem Kerncurriculum des Teilstudiengangs „Rechtswissenschaften" des Zwei-Fächer-Bachelor-Studiengangs (2FBA) bei Vorliegen der jeweils erforderlichen Vorkenntnisse belegt werden. Empfohlen wird, insbesondere Module zu wählen, die einem der rechtswissenschaftlichen Modulpakete im berufsfeldbezogenen Profil des 2FBA zugeordnet sind, sowie die Teilnahme an einer Studienberatung.

IV. Key competencies in the graduate programme in Mathematics

Within the graduate programme in Mathematics, the Unit Mathematics offers the following modules.

Die Lehreinheit Mathematik bietet im Master-Studiengang "Mathematik" folgende Schlüsselkompetenzmodule an.

V. Master's thesis

By successfully completing a Master's thesis students earn 30 C.

VI. Additional optional modules ("Zusatzmodule") (graduate studies)

In addition to the compulsory, the elective compulsory and the elective modules, additional optional modules can be completed, a distinction is made between two classes.

Es können weitere als die erforderlichen Module als Zusatzmodule absolviert werden. Es wird zwischen den nachstehenden Gruppen unterschieden.

1. Additional optional modules ("Zusatzmodule") in Mathematics (graduate studies)

Upon written request the grades of additional optional modules ("Zusatzmodule") are counted towards the overall grade of the Master's Degree. This option is restricted to modules with numbers B.Mat.**** and M.Mat.**** and it is limited to a total of 30 C. These modules are listed as additional optional courses on the Master's Degree certificate and the Transcript of Records.

Auf Antrag werden Noten von freiwilligen Zusatzleistungen ("Zusatzmodule") in Modulen B.Mat.**** oder M.Mat.***** des Master-Studiengangs Mathematik im Umfang von höchstens 30 C bei der Berechnung des Gesamtergebnisses der Masterprüfung berücksichtigt. Diese Zusatzmodule werden als freiwillige Zusatzleistungen in Zeugnis und Zeugnisergänzung (Diploma Supplement) ausgewiesen.

2. Further additional optional modules (graduate studies)

Beyond the additional modules mentioned in the preceding item, further modules not required for the Master's Degree can be completed. These are listed as additional optional modules ("Zusatzmodule") on the Master's Degree certificate and the Transcript of Records, too. However, the respective grades will **not** count towards the overall grade of the Master's Degree. Pre-approval is required in case a module is not listed in this directory of modules.

Über die in dem vorhergehenden Punkt genannten Zusatzmodule hinaus können weitere, für den Masterabschluss nicht erforderliche Module als Zusatzmodule absolviert werden. Diese werden in Zeugnis und Zeugnisergänzung (Transcript of Records) als freiwillige Zusatzleistungen gelistet, jedoch bei der Berechnung des Gesamtergebnisses der Masterprüfung **nicht** berücksichtigt. Im Fall von Modulen, die nicht in diesem Modulverzeichnis genannt werden, muss die Belegung vorab genehmigt werden.

VII. Modulpakete "Mathematik" im Umfang von 36 C oder 18 C (belegbar ausschließlich im Rahmen eines anderen geeigneten Master-Studiengangs)

This paragraph is addressed to students in non-mathematics M.A. graduate programmes, only.

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Die Lehreinheit Mathematik bietet folgende Modulpakete für Studierende anderer Studiengänge an. Studierende des Master-Studiengangs „Mathematik" können das Modul B.Mat.1400 und die Module der Form B.Mat.2XXX ausschließlich als freiwillige Zusatzprüfungen absolvieren; dabei fließt die Note nicht in das Gesamtergebnis der Masterprüfung im Master-Studiengang „Mathematik" ein.

1. Zugangsvoraussetzungen

Für die Modulpakete „Mathematik" im Umfang von 36 C bzw. 18 C gelten folgende gemeinsame Zugangsvoraussetzungen:

Nachweis von Leistungen aus Grundlagen der Mathematik im Umfang von insgesamt wenigstens 33 C, darunter Grundlagen der Analysis im Umfang von insgesamt wenigstens 18 C (z.B. durch die Module B.Mat.0011 und B.Mat.0021) sowie der Analytischen Geometrie und Linearen Algebra im Umfang von insgesamt wenigstens 15 C (z.B. durch die Module B.Mat.0012 und B.Mat.0026). Ferner der Nachweis weiterführender Leistungen der reinen oder angewandten Mathematik im Umfang von insgesamt wenigstens 21 C.

2. Modulpaket "Mathematik" im Umfang von 36 C

Es müssen aus dem nachfolgenden Angebot Module im Umfang von insgesamt wenigstens 36 C erfolgreich absolviert werden. Es können weiterführende mathematische Module des Bachelor-Studiengangs „Mathematik" der Georg-August-Universität Göttingen (Modulnummern B.Mat.3XXX) oder mathematische Wahlpflichtmodule aus dem Modulhverzeichnis des Master-Studiengangs „Mathematik" der Georg-August-Universität Göttingen (Modulnummern M.Mat.4XXX) absolviert werden. Empfohlen werden folgende Module:

3. Modulpaket "Mathematik" im Umfang von 18 C

Es müssen aus dem nachfolgenden Angebot Module im Umfang von insgesamt wenigstens 18 C erfolgreich absolviert werden. Es können weiterführende mathematische Module des Bachelor-Studiengangs „Mathematik" der Georg-August-Universität Göttingen (Modulnummern B.Mat.3XXX) oder mathematische Wahlpflichtmodule aus dem Modulverzeichnis des Master-Studiengangs „Mathematik" der Georg-August-Universität Göttingen (Modulnummern M.Mat.4XXX) absolviert werden. Empfohlen werden folgende Module:

VIII. Methods of examination and glossary

Methods of examination

As far as in this module handbook a module description is published in the English language the following mapping applies:

Soweit in diesem Modulverzeichnis Modulbeschreibungen in englischer Sprache veröffentlicht werden, gilt für die verwendeten Prüfungsformen nachfolgende Zuordnung:

- Oral examination = mündliche Prüfung [§ 15 Abs. 8 APO]
- Written examination = Klausur [§ 15 Abs. 9 APO]
- Term paper = Hausarbeit [§ 15 Abs. 11 APO]
- Presentation = Präsentation [§ 15 Abs. 12 APO]
- Presentation and written report = Präsentation mit schriftlicher Ausarbeitung [§ 15 Abs. 12 APO]

Glossary

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

PStO = Prüfungs- und Studienordnung für den Bachelor/Master-Studiengang "Mathematik"

WLH = Weekly lecture hours = SWS

Programme coordinator = Studiengangsbeauftrage/r

Georg-August-Universität Göttingen	5 C
Modul B.Inf.1206: Datenbanken	3 SWS
English title: Databases	

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Die Studierenden kennen die theoretischen Grundlagen sowie technischen Konzepte von Datenbanksystemen. Mit den erworbenen Kenntnissen in konzeptueller Modellierung und praktischen Grundkenntnissen in der am weitesten verbreiteten Anfragesprache "SQL" können sie einfache Datenbankprojekte durchführen. Sie wissen, welche grundlegende Funktionalität ihnen ein Datenbanksystem dabei bietet und können diese nutzen. Sie können sich ggf. auf der Basis dieser Kenntnisse mit Hilfe der üblichen Dokumentation in diesem Bereich selbständig weitergehend einarbeiten. Die Studierenden verstehen den Nutzen eines fundierten mathematisch-theoretischen Hintergrundes auch im Bereich praktischer Informatik.	Präsenzzeit: 42 Stunden Selbststudium: 108 Stunden

Lehrveranstaltung: Datenbanken (Vorlesung, Übung)	3 SWS
Inhalte: Konzeptuelle Modellierung (ER-Modell), relationales Modell, relationale Algebra (als theoretische Grundlage der Anfragekonzepte), SQL-Anfragen, -Updates und Schemaerzeugung, Transaktionen, Normalisierungstheorie. Literatur: R. Elmasri, S.B. Navathe: Grundlagen von Datenbanksystemen - Ausgabe Grundstudium (dt. Übers.), Pearson Studium (nach Praxisrelevanz ausgewählte Themen).	

Prüfung: Klausur (120 Min.) oder mündliche Prüfung (ca. 20 Min.)	5 C

Prüfungsanforderungen:	
Nachweis über aufgebaute weiterführende Kompetenzen in den folgenden Bereichen: theoretische Grundlagen sowie technische Konzepte von Datenbanksystemen, konzeptuelle Modellierung und praktische Grundkenntnisse in der am weitesten verbreiteten Anfragesprache "SQL" in ihrer Anwendung auf einfache Datenbankprojekte, Nutzung grundlegender Funktionalitäten von Datenbanksystem, mathematisch-theoretischer Hintergründe in der praktischen Informatik. Fähigkeit, die vorstehenden Kompetenzen weiter zu vertiefen.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Inf.1101
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Wolfgang May
Angebotshäufigkeit: jährlich	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 100	

Georg-August-Universität Göttingen **Modul B.Mat.0720: Mathematische Anwendersysteme (Grundlagen)** *English title: Mathematical application software*	3 C 2 SWS

Lernziele/Kompetenzen: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls haben die Studierenden • die Befähigung zum sicheren Umgang mit mathematischen Anwendersystemen erworben; • die Grundprinzipien der Programmierung erfasst; • Erfahrungen mit elementaren Algorithmen und deren Anwendungen gesammelt. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Kenntnisse über mathematische Anwendersysteme erworben. Sie • haben die Fähigkeit erworben, Algorithmen in mathematischen Anwendersystemen umzusetzen; • sind mit dem Einsatz von mathematischen Anwendersystemen bei Präsentationen vertraut.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden

Lehrveranstaltung: Blockkurs *Inhalte*: Blockkurs bestehend aus Vorlesung, Übungen und Praktikum, z.B. "Einführung in ein Mathematisches Anwendersystem"	2 SWS

Prüfung: Klausur (90 Minuten) **Prüfungsvorleistungen:** B.Mat.0720.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorstellen von Lösungen in den Übungen	3 C

Prüfungsanforderungen: Grundkenntnisse in einem mathematischen Anwendersystem (z.B. MuPAD, MATLAB oder Sage)	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0011, B.Mat.0012
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiendekan/in Mathematik
Angebotshäufigkeit: jedes Wintersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen **Modul B.Mat.0721: Mathematisch orientiertes Programmieren** *English title: Mathematics related programming*	6 C 3 SWS

Lernziele/Kompetenzen: **Lernziele:** Das erfolgreiche Absolvieren des Moduls ermöglicht den Studierenden den sicheren Umgang mit mathematischen Anwendersystemen. Die Studierenden • erwerben die Befähigung zum sicheren Umgang mit mathematischen Anwendersystemen, • erfassen die Grundprinzipien der Programmierung, • sammeln Erfahrungen mit elementaren Algorithmen und deren Anwendungen, • verstehen die Grundlagen der Programmierung in einer high-level Programmiersprache, • lernen Kontroll- und Datenstrukturen kennen, • erlernen die Grundzüge des imperativen und funktionalen Programmierens, • setzen Bibliotheken zur Lösung naturwissenschaftlicher Fragestellungen ein, • erlernen verschiedene Methoden der Visualisierung, • beherrschen die Grundtechniken der Projektverwaltung (Versionskontrolle, Arbeiten im Team). **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Techniken für das Lösen mathematisch/physikalischer Problemstellungen mit der Hilfe einer high-level Programmiersprache erlernt.	**Arbeitsaufwand:** Präsenzzeit: 42 Stunden Selbststudium: 138 Stunden

Lehrveranstaltung: Blockkurs *Inhalte*: Blockkurs bestehend aus Vorlesung, Übungen und Praktikum, z.B. "Mathematisch orientiertes Programmieren"	2 SWS

Prüfung: Klausur (90 Minuten) oder mündliche Prüfung (ca. 20 min)	6 C

Prüfungsanforderungen: Nachweis über den Erwerb der folgenden Kenntnisse und Fähigkeiten. Die Teilnehmer/innen weisen grundlegende Techniken für das Lösen mathematisch/physikalischer Problemstellungen mit der Hilfe einer Programmiersprache nach.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0011, B.Mat.0012
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiendekan/in Mathematik
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**

zweimalig	Bachelor: 1 - 6; Master: 1 - 4
Maximale Studierendenzahl: 120	

Bemerkungen:

Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen	9 C
Modul B.Mat.0730: Praktikum Wissenschaftliches Rechnen	4 SWS
English title: Practical course in scientific computing	

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele:	Präsenzzeit:
Nach erfolgreichem Absolvieren des Moduls besitzen die Studierenden praktische Erfahrungen im wissenschaftlichen Rechnen. Sie	56 Stunden
• erstellen größere Programmierprojekte in Einzel- oder Gruppenarbeit;	Selbststudium:
• erwerben und festigen Programmierkenntnisse;	214 Stunden
• haben Erfahrungen mit grundlegenden Verfahren zur numerischen Lösung von mathematischen Problemen.	
Kompetenzen:	
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,	
• mathematische Algorithmen und Verfahren in einer Programmiersprache oder einem Anwendersystem zu implementieren;	
• spezielle numerische Bibliotheken zu nutzen;	
• komplexe Programmieraufgaben so zu strukturieren, dass sie effizient in Gruppenarbeit bewältigt werden können.	

Lehrveranstaltung: Praktikum Wissenschaftliches Rechnen	4 SWS

Prüfung: Präsentation (ca. 30 Minuten) oder Hausarbeit (max. 50 Seiten ohne Anhänge)	9 C
Prüfungsvorleistungen:	
Regelmäßige Teilnahme im Praktikum	

Prüfungsanforderungen:	
• Grundkenntnisse der numerischen Mathematik	
• gute Programmierkenntnisse	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
keine	B.Mat.0721, B.Mat.1300
	Kenntnis des objektorientierten Programmierens

Sprache:	**Modulverantwortliche[r]:**
Deutsch	Studiengangsbeauftragte(r)

Angebotshäufigkeit:	**Dauer:**
jedes Semester	1 Semester

Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	Bachelor: 4 - 6; Master: 1 - 4

Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:	

Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen **Modul B.Mat.0740: Stochastisches Praktikum** *English title: Practical course in stochastics*	9 C 6 SWS

Lernziele/Kompetenzen:	Arbeitsaufwand:
Lernziele: Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit den grundlegenden Eigenschaften und Methoden einer stochastischen Simulations- und Analyse-Software (z.B. "R" oder Matlab) vertraut. Sie haben in Projektarbeit Spezialkenntnisse in Stochastik erworben. Sie • implementieren und interpretieren selbstständig einfache stochastische Problemstellungen in einer entsprechenden Software; • schreiben selbständig einfache Progamme in der entsprechenden Software; • beherrschen einige grundlegende Techniken der statistischen Datenanalyse und stochastischen Simulation, wie etwa der deskriptiven Statistik, der linearen, nichtlinearen und logistischen Regression, der Maximum-Likelihood-Schätzmethode, sowie von verschiedenen Testverfahren und Monte-Carlo-Simulationsmethoden. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage • eine stochastische Simulations- und Analyse-Software auf konkrete stochastische Problemstellungen anzuwenden und die erhaltenen Resultate fachgerecht zu präsentieren; • statistische Daten und ihre wichtige Eigenschaften adäquat zu visualisieren und interpretieren.	Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden

Lehrveranstaltung: Stochastisches Praktikum	6 SWS

Prüfung: Präsentation (ca. 45 Minuten) mit schriftlicher Ausarbeitung (max. 50 Seiten ohne Anhänge)	9 C

Prüfungsanforderungen: Weiterführende Kenntnisse in Stochastik	

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: B.Mat.2400
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 4 - 6; Master: 1 - 4
Maximale Studierendenzahl:	

nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Instituts für Mathematische Stochastik

Georg-August-Universität Göttingen **Modul B.Mat.0911: Ein Mehrbenutzerbetriebssystem in der Praxis: Einzelbetrieb** *English title: Working with a multi-user operating system - single user modus*	3 C (Anteil SK: 3 C) 2 SWS

Lernziele/Kompetenzen: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über fundierte Grundlagenkenntnisse eines Mehrbenutzerbetriebssystems im Einzelbetrieb. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage • mit einem Mehrbenutzerbetriebssystem auf der Ebene einfacher Systemverwaltung im Einzelbetrieb umzugehen; • Skripte zur effektiven Aufgabenbewältigung zu erstellen.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden

Lehrveranstaltung: Vorlesung (Vorlesung) *Inhalte*: Vorlesung mit Übungen	2 SWS

Prüfung: Klausur (90 Minuten), unbenotet **Prüfungsvorleistungen:** B.Mat.0911.Ue: Teilnahme an der Veranstaltung und regelmäßige Abgabe von Lösungen zu den Übungsaufgaben	3 C

Prüfungsanforderungen: Grundkenntnisse in der Erstellung von Skripten, sicherer Umgang mit und Zuordnung von Begriffen aus einem Mehrbenutzerbetriebssystem im Einzelbetrieb	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Grundkenntnisse im Umgang mit einem Computer
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Wintersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: • Dozent/in: Lehrpersonen des Mathematischen Instituts • Schlüsselkompetenz im Bereich "EDV/IKT-Kompetenz (IKT=Informations- und Kommunikationstechnologie)", auch für Studierende anderer Fakultäten.

- Nicht verwendbar als Schlüsselkompetenz für Studierende im Zwei-Fächer Bachelor-Studiengang mit Fach Informatik oder im Bachelor/Master-Studiengang "Angewandte Informatik"
- Im Bachelor-Studiengang "Angewandte Informatik" verwendbar als Wahlmodul im Bereich der Kerninformaitk

Georg-August-Universität Göttingen	3 C (Anteil SK: 3 C)
Modul B.Mat.0912: Ein Mehrbenutzerbetriebssystem in der Praxis: Netzwerkbetrieb *English title: Working with a multi-user operating system - network services*	2 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele:	Präsenzzeit:
	28 Stunden
Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über fundierte	Selbststudium:
	62 Stunden
• Grundlagenkenntnisse eines Mehrbenutzerbetriebssystems im Netzwerkbetrieb;	
• theoretische Grundlagen von Netzwerkbetriebssystemen.	
Kompetenzen:	
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage	
• mit einem Mehrbenutzerbetriebssystem auf der Ebene einfacher Systemverwaltung im Netzwerkbetrieb umzugehen;	
• Skripte zur effektiven Aufgabenbewältigung zu erstellen;	
• Netzwerkprotokolle praktisch anzuwenden.	

Lehrveranstaltung: Vorlesung (Vorlesung) *Inhalte*: Vorlesung mit Übungen	

Prüfung: Klausur (90 Minuten), unbenotet **Prüfungsvorleistungen:** B.Mat.0912.Ue: Teilnahme an der Veranstaltung und regelmäßige Abgabe von Lösungen zu den Übungsaufgaben	3 C

Prüfungsanforderungen: Grundkenntnisse in der Erstellung von Skripten im Netzwerkbetrieb, sicherer Umgang mit und Zuordnung von Begriffen aus einem Mehrbenutzerbetriebssystem im Netzwerkbetrieb	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0911
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: • Dozent/in: Lehrpersonen des Mathematischen Instituts

- Schlüsselkompetenz im Bereich "EDV/IKT-Kompetenz (IKT=Informations- und Kommunikationstechnologie)", auch für Studierende anderer Fakultäten.
- Nicht verwendbar als Schlüsselkompetenz für Studierende im Zwei-Fächer Bachelor-Studiengang mit Fach Informatik oder im Bachelor/Master-Studiengang "Angewandte Informatik"
- Im Bachelor-Studiengang "Angewandte Informatik" verwendbar als Wahlmodul im Bereich der Kerninformaitk

Georg-August-Universität Göttingen **Modul B.Mat.0921: Einführung in TeX/LaTeX und praktische Anwendungen** *English title: Introduction to TeX/LaTeX with applications*	3 C (Anteil SK: 3 C) 2 SWS

| **Lernziele/Kompetenzen:**
Lernziele:

Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit dem Einsatz von TeX oder LaTeX zur Erstellung von wissenschaftlichen Texten und Vorträgen vertraut. Sie

• sind vertraut mit ordentlicher Dokumentengliederung;
• erstellen Literaturangaben und Querverweise;
• erzeugen mathematische Formeln;
• erzeugen Grafiken und binden sie ein.

Kompetenzen:

Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,

• einfache Dokumente mit LaTeX zu erstellen;
• ansprechende Vortragsfolien mit LaTeX zu erzeugen. | **Arbeitsaufwand:**
Präsenzzeit:
28 Stunden
Selbststudium:
62 Stunden |

| **Lehrveranstaltung: Blockkurs**
Inhalte:
Einwöchige Blockveranstaltung mit Praktikum | |

| **Prüfung: Hausarbeit (max. 10 Seiten), unbenotet**
Prüfungsvorleistungen:
Regelmäßige Teilnahme an der Veranstaltung
Prüfungsanforderungen:
Erstellung eines wissenschaftlichen Portfolios mit TeX/LaTeX und der Folien für eine Präsentation mit Beamer-TeX. | 3 C |

| **Prüfungsanforderungen:**
Sicherer Umgang mit den grundlegenden Funktionen von LaTeX und Bearmer-TeX | |

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Grundkenntnisse im Umgang mit einem Computer.
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Mathematischen Instituts

Georg-August-Universität Göttingen **Module B.Mat.0922: Mathematics information services and electronic publishing**	3 C (incl. key comp.: 3 C) 2 WLH

Learning outcome, core skills: **Learning outcome:** After having successfully completed the module, students are familiar with the basics of mathematics information services and electronic publishing. They • work with popular information services in mathematics and with conventional, non-electronic as well as electronic media; • know a broad spectrum of mathematical information sources including classification principles and the role of meta data; • are familiar with current development in the area of electronic publishing in the subject mathematics. **Core skills:** After successfull completion of the module students have acquired subject-specific information competencies. They • have suitable research skills; • are familiar with different information and specific publication services.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture) *Contents*: Lecture course with project report	

Examination: Written examination (90 minutes), not graded **Examination prerequisites:** Regular participation in the course	3 C

Examination requirements: Application of the acquired skills in individual projects in the area of mathematical information services and electronic publishing	

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

Additional notes and regulations:

Instructors: Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen	4 C (Anteil SK: 4 C)
Modul B.Mat.0931: Tutorentraining	2 SWS
English title: Coaching of teaching assistants	

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele:	Präsenzzeit:
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit theoretischen und praktischen Fragestellungen der Vermittlung mathematischen Wissens vertraut. Sie werden befähigt,	28 Stunden Selbststudium: 92 Stunden
• mathematische Inhalte an Studierende im ersten Semester zu vermitteln;	
• eine heterogene Übungsgruppe zu leiten.	
• verschiedene Lehrmethoden und Visualisierungstechniken einzusetzen;	
• souverän aufzutreten.	
Kompetenzen:	
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,	
• Rhetorik- und Präsentationstechniken einzusetzen;	
• Teamkompetenzen (insb. Motivationsfähigkeit und sicherer Umgang mit Konfliktsituationen) einzusetzen;	
• Methoden des Zeitmanagements zu verwenden;	
• interkulturelle Kompetenzen, insbesondere interkulturelle Kommunikationswege einzusetzen.	

Lehrveranstaltung: Integratives Projekt	
Inhalte:	
Neben dem Leiten einer Übungsgruppe während des gesamten Semesters oder einer Blockveranstaltung beinhaltet das Projekt ein Vorbereitungsseminar und ein Abschlussseminar sowie begleitende Kurzveranstaltungen.	

Prüfung: Präsentation [Übungsstunde] (ca. 45 Minuten) und schriftliche Ausarbeitung (max. 5 Seiten), unbenotet	4 C
Prüfungsvorleistungen:	
Teilnahme an der Veranstaltung	

Prüfungsanforderungen:	
Nachweis des Erreichens der Lernziele und Erwerbs der Kompetenzen durch Umsetzung in einer Übungsstunde	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
Übertragung der Leitung einer Übungsgruppe zu einer Lehrveranstaltung der Fakultät für Mathematik und Informatik im gleichen Semester	keine
Sprache:	**Modulverantwortliche[r]:**
Deutsch, Englisch	Studiengangsbeauftragte/r
Angebotshäufigkeit:	**Dauer:**

jedes Wintersemester	1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 3 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Mathematischen Instituts

| Georg-August-Universität Göttingen | 3 C (Anteil SK: 3 C) |
| **Modul B.Mat.0932: Vermittlung mathematischer Inhalte an ein Fachpublikum**
English title: Communicating mathematical topics to a professional audience | 2 SWS |

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele: Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit theoretischen und praktischen Grundlagen der Vermittlung mathematischen Wissens vertraut. Sie • schätzen das Niveaus der Zielgruppe einer mathematischen Darbietung ein; • strukturieren Präsentationen gut; • beherrschen sicher stilistische und technische Aspekte der Darbietung; • wählen adäquate Hilfsmittel (z.B. zur Visualisierung); • steuern die Diskussion mit dem Publikum. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über je nach Veranstaltung verschiedene Kommunikations- und Vermittlungskompetenzen sowie ggf. Fremdsprachenkompetenzen.	Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden

| **Lehrveranstaltung: Veranstaltung mit theoretischem und praktischem Anteil, kann ggf. als Blockveranstaltung angeboten werden oder als Teil eines mathematischen Seminars.** (Seminar) | |

| **Prüfung: Präsentation (ca. 45 Minuten), unbenotet**
Prüfungsvorleistungen:
Teilnahme an der Veranstaltung | 3 C |

| **Prüfungsanforderungen:**
Nachweis des Erreichens der Lernziele durch Anfertigen einer Darbietung zur Vermittlung mathematischer Inhalte (Format der Darbietung je nach Veranstaltung) | |

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: keine Angabe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 3 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

| **Bemerkungen:**
Dozent/in: Lehrpersonen der Lehreinheit Mathematik |

Georg-August-Universität Göttingen **Modul B.Mat.0935: Historische, museumspädagogische und technische Aspekte für den Aufbau, Erhalt und die Nutzung wissenschaftlicher Modellsammlungen** *English title: Historical, museum-related, and technical aspects of the building-up, the maintenance and the use of scientific collections*	4 C (Anteil SK: 4 C) 2 SWS

Lernziele/Kompetenzen: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über Kenntnisse des Planens und Gestaltens von Mathematikunterricht und mathematikdidaktischen Forschungsprojekten **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls nutzen die Studierenden Kenntnisse der mathematischen Wissensvermittlung. Sie • ordnen wissenschaftliche Modellsammlungen in ihren historischen Kontext ein, • nutzen museumspädagogische Ansätze für die Vermittlung mit Hilfe von Objekten, • kennen Beispiele für Techniken, die für den Aufbau und Erhalt von Objekten in Modellsammlungen erforderlich sind.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 92 Stunden

Lehrveranstaltung: Seminar	2 SWS

Prüfung: Portfolio (max. 5000 Zeichen), unbenotet	4 C

Prüfungsanforderungen: Erarbeitung historischer, museumspädagogischer und technischer Aspekte eines Modells oder mehrerer Modelle in Kontexten von Sammlungen.

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: keine Angabe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Master: 1 - 4
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: Dozent/in: Lehrpersonen des Mathematischen Instituts

Georg-August-Universität Göttingen	4 C (Anteil SK: 4 C)
Modul B.Mat.0936: Medienbildung zu mathematischen Objekten und Problemen	2 SWS
English title: Media education for mathematical objects and problems	

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele:	Präsenzzeit:
Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über Kenntnisse des Medienunterstützen Lehrens und Lernens zu mathematischen Objekten und Problemen.	28 Stunden Selbststudium: 92 Stunden
Kompetenzen:	
Nach erfolgreichem Absolvieren des Moduls ordnen die Studierenden wissenschaftliche Modellsammlungen in ihren historischen Kontext ein. Sie	
• nutzen Kenntnisse der Medienbildung zur mathematischen Wissensvermittlung, • vergleichen unterschiedliche Designs für die Illustration mathematischer Objekte und Probleme, • implementieren beispielhaft unterschiedliche medientechnische Realisierungen mathematischer • Objekte.	

Lehrveranstaltung: Seminar	2 SWS

Prüfung: Portfolio (max. 5000 Zeichen), unbenotet	4 C

Prüfungsanforderungen: Erarbeitung medienbezogener Aspekte eines Modells oder mehrerer Modelle in Kontexten von Sammlungen.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: keine Angabe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Master: 1 - 4
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: **Dozent/in:** Lehrpersonen des Mathematischen Instituts

Georg-August-Universität Göttingen	3 C (Anteil SK: 3 C)
Modul B.Mat.0940: Mathematik in der Welt, in der wir leben *English title: The mathematical nature of the world we are living in*	2 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele:	Präsenzzeit:
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit der Rolle der Mathematik in unserer Gesellschaft vertraut, wobei die Schwerpunktsetzung je nach Veranstaltung ausgestaltet wird. Die Studierenden	28 Stunden Selbststudium: 62 Stunden
• entwickeln ein stärkeres Bewusstsein für die Rolle der Mathematik in anderen Fachdisziplinen; • erwerben ein tieferes Verständnis für die Bedeutung der Mathematik für den (technologischen) Fortschritt; • erkennen die Bedeutung der Mathematik für das Verständnis von Vorgängen und Erscheinungen in der Natur; • verstehen die Rolle der Mathematik in der Gesellschaft.	
Kompetenzen:	
Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über verschiedene Kompetenzen, je nach Ausgestaltung der Lehrveranstaltung haben sie	
• ihre Befähigung zum Logischen Denken ausgebaut; • das mathematische Interpretieren von Observationen und Daten in einem außermathematischem Kontext erlernt; • die Transferfähigkeit von abstraktem Wissen auf reelle Situationen erworben; • ihre Methodenkompetenz im mathematischen Bereich gestärkt.	

Lehrveranstaltung: Vorlesung oder Seminar	

Prüfung: Klausur (90 Minuten) oder Hausarbeit (max. 10 Seiten), unbenotet	3 C

Prüfungsanforderungen:	
Nachweis des Erreichens der Lernziele durch Anwendung auf ausgewählte Problemstellungen	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jährlich	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen der Lehreinheit Mathematik

Georg-August-Universität Göttingen	3 C (Anteil SK: 3 C)
Modul B.Mat.0950: Mitgliedschaft in der studentischen oder akademischen Selbstverwaltung	1 SWS
English title: Membership in the student or academic self-government	

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Die Studierenden erwerben zentrale Kompetenzen der Planung, Organisation, Präsentation sowie Grundkenntnisse in der Projektplanung. Sie erwerben Kompetenzen in Rhetorik, in Selbstpräsentation und in freier Rede. Im Praxisteil erlangen die Studierenden vertiefte Kenntnisse in den Bereichen Moderationstechniken, Gesprächsführung sowie Entscheidungs- und Konfliktlösungsverhalten in Gruppen.	Präsenzzeit: 14 Stunden Selbststudium: 76 Stunden

Lehrveranstaltung: Gremienveranstaltung	

Prüfung: Hausarbeit (max. 5 Seiten), unbenotet	3 C

Prüfungsanforderungen:	
Die Studierenden erbringen den Nachweis der Befähigung, dass sie Erfahrungen aus der Praxis mit theoretischen Wissen verknüpfen und Methoden der Reflektion anwenden können.	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
Mitgliedschaft in mindestens einem der folgenden Gremien: 1. Fakultätsrat der Fakultät für Mathematik und Informatik oder eine seiner Kommissionen 2. Senat der Universität oder einer seiner Kommissionen 3. Vorstand des Studentenwerks	keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen:	
Dozent/in: Studiendekan/in Mathematik oder Studienreferent/in Mathematik	

Georg-August-Universität Göttingen

Modul B.Mat.0951: Ehrenamtliches Engagement in einem mathematischen Umfeld

English title: Civic engagement in a mathematical environment

| 3 C (Anteil SK: 3 C) |
| 1 SWS |

Lernziele/Kompetenzen:

Die Studierenden erwerben zentrale Kompetenzen der Planung, Organisation, Präsentation sowie Grundkenntnisse in der Projektplanung. Sie erwerben Kompetenzen in Rhetorik, in Selbstpräsentation und in freier Rede. Im Praxisteil erlangen die Studierenden vertiefte Kenntnisse in mathematischer Wissensvermittlung sowie in mindestens einem der folgenden Bereichen:

- Moderationstechniken,
- Gesprächsführung
- Entscheidungs- und Konfliktlösungsverhalten in Gruppen.

Arbeitsaufwand:

Präsenzzeit:
14 Stunden
Selbststudium:
76 Stunden

Lehrveranstaltung: Projektarbeit

Prüfung: Portfolio (max. 5 Seiten), unbenotet | 3 C

Prüfungsanforderungen:

Die Studierenden erbringen den Nachweis der Befähigung, dass sie Erfahrungen aus der Praxis mit theoretischen Wissen verknüpfen und Methoden der Reflektion anwenden können.

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
Ehrenamtliche Tätigkeit ohne Entgelt oder Aufwandsentschödigung, z.B. 1. bei der Durchführung der Mathematik-Olympiade oder dem Bundeswettbewerb Mathematik 2. Nachhilfe im Rahmen von sozialen Projekten 3. Mathematisches Korrespondenz-Zirkel 4. MatheCamp	keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen:

Dozent/in: Studiendekan/in Mathematik oder Studienreferent/in Mathematik

Georg-August-Universität Göttingen	3 C (Anteil SK: 3 C)
Modul B.Mat.0952: Organisation einer mathematischen Veranstaltung *English title: Event management in mathematics*	2 SWS

| **Lernziele/Kompetenzen:**
 Lernziele:

 Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Problemen, die bei der Organisation einer mathematischen Veranstaltung entstehen, vertraut. Dabei wird die Schwerpunktsetzung je nach dem zu organisierenden Veranstaltungsprojekt ausgestaltet, zu dem die Studierenden einen abgegrenzten, aktiven Beitrag leisten.

 Kompetenzen:

 Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über verschiedene Kompetenzen, je nach Ausgestaltung des Veranstaltungsprojekts erwerben sie

 • Organisations- und Managementkompetenzen;
 • Kompetenzen im Informations- und Zeitmanagement;
 • Teamkompetenz. | **Arbeitsaufwand:**
 Präsenzzeit:
 28 Stunden
 Selbststudium:
 62 Stunden |

Lehrveranstaltung: Integratives Projekt *Inhalte*: *Angebotshäufigkeit:* jährlich	

Prüfung: Projektpräsentation (ca. 20 Minuten) oder Hausarbeit (max. 5 Seiten), unbenotet	3 C

Prüfungsanforderungen: Nachweis der Kompetenzen und Fähigkeiten durch einen abgegrenzten, aktiven Beitrag zu einem Veranstaltungsprojekt.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: keine Angabe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: Dozent/in: Lehrpersonen der Lehreinheit Mathematik

Georg-August-Universität Göttingen **Modul B.Mat.0970: Betriebspraktikum** *English title: Internship*	8 C (Anteil SK: 8 C)

Lernziele/Kompetenzen: Nach erfolgreichem Absolvieren des Moduls besitzen die Studierenden Kompetenzen in projektbezogener und forschungsorientierter Teamarbeit sowie im Projektmanagement. Sie sind mit Verfahren, Werkzeugen und Prozessen der Mathematik sowie dem organisatorischen und sozialen Umfeld der Praxis vertraut.	**Arbeitsaufwand:** Präsenzzeit: 0 Stunden Selbststudium: 240 Stunden

Prüfung: Präsentation (ca. 20 Minuten) mit schriftlicher Ausarbeitung (max. 10 Seiten), unbenotet **Prüfungsvorleistungen:** Bescheinigung über die erfolgreiche Erfüllung der gestellten Aufgaben gemäß Praktikumsplan	8 C

Prüfungsanforderungen: Erfolgreiche Bearbeitung der gestellten Aufgaben gemäß zwischen dem oder der Studierenden, der Lehrperson und dem Betrieb zu vereinbarendem Praktikumsplan	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 4 - 6; Master: 1 - 4; Promotion: 1 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: Dozent/in: Lehrpersonen der Lehreinheit Mathematik

Georg-August-Universität Göttingen **Modul B.Mat.1400: Grundlagen der Maß- und Wahrscheinlichkeits-theorie** *English title: Foundations of measure and probability theory*	9 C 6 SWS

Lernziele/Kompetenzen: **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	**Arbeitsaufwand:** Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden

- kennen 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 abzählbar unendlichen Produkträumen aus;
- formulieren wahrscheinlichkeitstheoretische Aussagen mit Wahrscheinlichkeitsräumen, Wahrscheinlichkeitsmaßen und Zufallsvariablen;
- 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;
- kennen charakteristische Funktionen und deren Anwendungen;
- besitzen Grundkenntnisse über bedingte Wahrscheinlichkeiten und bedingte Erwartungswerte;
- verwenden das schwache und starke Gesetz der großen Zahlen und den zentralen Grenzwertsatz.

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;
- grundlegende Grenzwertsätze der Wahrscheinlichkeitstheorie zu verwenden.

Lehrveranstaltungen:	
1. Maß- und Wahrscheinlichkeitstheorie (Vorlesung)	4 SWS
2. Maß- und Wahrscheinlichkeitstheorie - Übung (Übung)	2 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:**	9 C

B.Mat.1400.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	

Prüfungsanforderungen: Nachweis der Grundkenntnisse in Stochastik	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0021, B.Mat.0022
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 4 - 6
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: Dozent/in: Lehrpersonen des Instituts für Mathematische Stochastik

Georg-August-Universität Göttingen **Modul B.Mat.2100: Partielle Differenzialgleichungen** *English title: Partial differential equations*	9 C 6 SWS

Lernziele/Kompetenzen: **Lernziele:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit grundlegenden Typen von Differenzialgleichungen und Eigenschaften ihrer Lösungen vertraut. Sie • beschreiben grundlegende Eigenschaften von Lösungen der Laplace-, Wärmeleitungs- und Wellengleichung und zugehöriger Rand- bzw. Anfangs-Randwertprobleme; • sind mit grundlegenden Eigenschaften von Fourier-Transformation und Sobolev-Räumen auf beschränkten und unbeschränkten Gebieten vertraut; • analysieren die Lösbarkeit von Randwertproblemen für elliptische Differenzialgleichungen mit variablen Koeffizienten; • analysieren die Regularität von Lösungen elliptischer Randwertprobleme im Inneren und am Rand. **Kompetenzen:** Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, • den Typ einer partiellen Differenzialgleichung zu erkennen und auf qualitative Eigenschaften ihrer Lösungen zu schließen; • mathematisch relevante Fragestellungen zu partiellen Differenzialgleichungen zu erkennen; • den Einfluss von Randbedingungen und Funktionenräumen auf Existenz, Eindeutigkeit und Stabilität von Lösungen zu beurteilen.	**Arbeitsaufwand:** Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden

Lehrveranstaltungen:	
1. Partielle Differenzialgleichungen (Vorlesung)	4 SWS
2. Partielle Differenzialgleichungen - Übung (Übung)	2 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** B.Mat.2100.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Prüfungsanforderungen: Nachweis der Grundkenntnisse über partielle Differenzialgleichungen	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0021, B.Mat.0022
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: zweijährig jeweils im Wintersemester	**Dauer:** 1 Semester

Wiederholbarkeit:	Empfohlenes Fachsemester:
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Mathematischen Instituts oder des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen **Modul B.Mat.2110: Funktionalanalysis** *English title: Functional analysis*	9 C 6 SWS

| **Lernziele/Kompetenzen:**
Lernziele:

Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit funktionalanalytischer Denkweise und den zentralen Resultaten aus diesem Gebiet vertraut. Sie

• gehen sicher mit den gängigsten Beispielen von Funktionen- und Folgenräumen wie Lp, lp und Räumen stetiger Funktionen um und analysieren deren funktionalanalytische Eigenschaften;
• wenden die grundlegenden Sätze über lineare Operatoren in Banach-Räumen an, insbesondere die Sätze von Banach-Steinhaus, Hahn-Banach und den Satz über die offene Abbildung;
• argumentieren mit schwachen Konvergenzbegriffen und den grundlegenden Eigenschaften von Dual- und Bidualräumen;
• erkennen Kompaktheit von Operatoren und analysieren die Lösbarkeit linearer Operatorgleichungen mit Hilfe der Riesz-Fredholm-Theorie;
• sind mit grundlegenden Begriffen der Spektraltheorie und dem Spektralsatz für beschränkte, selbstadjungierte Operatoren vertraut.

Kompetenzen:

Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,

• in unendlich-dimensionalen Räumen geometrisch zu argumentieren;
• Aufgabenstellungen in funktionalanalytischer Sprache zu formulieren und zu analysieren;
• die Relevanz funktionalanalytischer Eigenschaften wie der Wahl eines passenden Funktionenraums, Vollständigkeit, Beschränktheit oder Kompaktheit zu erkennen und zu beschreiben. | **Arbeitsaufwand:**
Präsenzzeit:
84 Stunden
Selbststudium:
186 Stunden |

Lehrveranstaltungen: **1. Funktionalanalysis** (Vorlesung)	4 SWS
2. Funktionalanalysis - Übung (Übung)	2 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** B.Mat.2110.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Prüfungsanforderungen: Nachweis der Grundkenntnisse über Funktionalanalysis	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0021, B.Mat.0022

Sprache:	Modulverantwortliche[r]:
Deutsch	Studiengangsbeauftragte/r
Angebotshäufigkeit:	**Dauer:**
jedes Sommersemester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:

Dozent/in: Lehrpersonen des Mathematischen Instituts oder des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen **Modul B.Mat.2120: Funktionentheorie** *English title: Complex analysis*	9 C 6 SWS

| **Lernziele/Kompetenzen:**

Lernziele:

Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der komplexen Analysis vertraut. Sie

• gehen sicher mit dem Holomorphiebegriff um und kennen gängige Beispiele von holomorphen Funktionen;
• beherrschen insbesondere die verschiedenen Definitionen für Holomorphie und erkennen deren Äquivalenz;
• verstehen den Cauchyschen Intergralsatz und den Residuensatz und wenden diese Sätze innerhalb der Funktionentheorie an;
• erarbeiten weitere ausgewählte Themen der Funktionentheorie;
• erlernen und vertiefen funktionentheoretische Herangehensweisen an mathematische Problemstellungen an Hand ausgewählter Beispiele.

Kompetenzen:

Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,

• sicher mit grundlegenden Methoden und Grundbegriffen aus der Funktionentheorie umzugehen;
• auf Basis funktionentheoretischer Denkweisen und Beweistechniken zu argumentieren;
• sich in verschiedene Fragestellungen im Bereich "Funktionentheorie" einzuarbeiten;
• funktionentheoretische Methoden auf weiterführende Themen aus der Funktionentheorie und verwandten Gebieten anzuwenden. | **Arbeitsaufwand:**
Präsenzzeit:
84 Stunden
Selbststudium:
186 Stunden |

Lehrveranstaltungen: **1. Funktionentheorie** (Vorlesung)	4 SWS
2. Funktionentheorie - Übung (Übung)	2 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** B.Mat.2120.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Prüfungsanforderungen: Nachweis der Grundkenntnisse in Funktionentheorie	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.0021, B.Mat.0022
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r

Angebotshäufigkeit:	Dauer:
jedes Sommersemester	1 Semester
Wiederholbarkeit:	Empfohlenes Fachsemester:
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Mathematischen Instituts

Georg-August-Universität Göttingen **Modul B.Mat.2200: Moderne Geometrie** *English title: Modern geometry*	9 C 6 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele: Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Methoden und Konzepten der modernen Geometrie vertraut. Abhängig vom weiterführenden Angebot stehen Methoden der elementaren Differenzialgeometrie oder grundlegende Konzepte der algebraischen Geometrie im Mittelpunkt. Die Studierenden - kennen die Grundlagen der Differenzialgeometrie von Kurven und Flächen; - sind mit den inneren Eigenschaften von Flächen vertraut; - lernen einfache globale Ergebnisse kennen; oder sie - kennen grundlegende Konzepte der algebraischen Geometrie in wichtigen Beispielen; - sind mit der Formulierung geometrischer Fragen in der Sprache der Algebra vertraut; - arbeiten mit zentralen Begriffen und Ergebnissen der kommutativen Algebra. **Kompetenzen:** Nach erfolgreichem Absolvieren dieses Moduls verfügen die Studierenden über grundlegende Kompetenzen in der modernen Geometrie und sind auf weiterführende Veranstaltungen in der Differenzialgeometrie oder in der algebraischen Geometrie vorbereitet. Sie sind in der Lage, - geometrische Fragestellungen mit Konzepten der Differenzialgeometrie oder der algebraischen Geometrie zu präzisieren; - Probleme anhand von Ergebnissen der Differenzialgeometrie oder der algebraischen Geometrie zu lösen; - mit Fragestellungen und Anwendungen des jeweiligen Gebiets umzugehen.	Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden

Lehrveranstaltungen:	
1. Vorlesung (Vorlesung)	4 SWS
2. Übung *Angebotshäufigkeit:* jedes Wintersemester	2 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** B.Mat.2200.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Prüfungsanforderungen: Nachweis der Grundkenntnisse über Geometrie	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**

keine	B.Mat.0021, B.Mat.0022
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 4 - 6
Maximale Studierendenzahl: nicht begrenzt	
Bemerkungen: Dozent/in: Lehrpersonen des Mathematischen Instituts	

Georg-August-Universität Göttingen	9 C
Modul B.Mat.2210: Zahlen und Zahlentheorie	6 SWS
English title: Numbers and number theory	

Lernziele/Kompetenzen:	Arbeitsaufwand:
Lernziele:	Präsenzzeit:
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der elementaren Zahlentheorie vertraut. Sie	84 Stunden Selbststudium: 186 Stunden
• erwerben grundlegende Kenntnisse über Zahlentheorie;	
• sind insbesondere mit Teilbarkeit, Kongruenzen, arithmetischen Funktionen, Reziprozitätsgesetz, elementaren diophantischen Gleichungen vertraut;	
• kennen die elementare Theorie p-adischer Zahlen;	
• sind mit weiteren ausgewählten Themen der Zahlentheorie vertraut.	
Kompetenzen:	
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,	
• elementare zahlentheoretische Denkweisen und Beweistechniken zu beherrschen;	
• mit Grundbegriffen und grundlegenden Methoden der Zahlentheorie zu argumentieren;	
• mit Begriffen und Methoden aus weiterführenden Themen der Zahlentheorie zu arbeiten.	

Lehrveranstaltungen:	
1. Zahlen und Zahlentheorie (Vorlesung)	4 SWS
2. Zahlen und Zahlentheorie - Übung (Übung)	2 SWS

Prüfung: Klausur (120 Minuten)	9 C
Prüfungsvorleistungen:	
B.Mat.2210.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	

Prüfungsanforderungen:	
Nachweis der Grundkenntnisse der Zahlentheorie	

Zugangsvoraussetzungen:	Empfohlene Vorkenntnisse:
keine	B.Mat.0021, B.Mat.0022
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Studiengangsbeauftragte/r
Angebotshäufigkeit:	**Dauer:**
jedes Sommersemester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Mathematischen Instituts

Georg-August-Universität Göttingen **Modul B.Mat.2300: Numerische Analysis** *English title: Numerical analysis*	9 C 6 SWS

Lernziele/Kompetenzen: 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.	**Arbeitsaufwand:** Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden

Lehrveranstaltungen: **1. Numerische Mathematik II - Übung**	2 SWS
2. Numerische Mathematik II	4 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** B.Mat.2300.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C

Prüfungsanforderungen: Nachweis weiterführender Kenntnisse in numerischer Mathematik	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.1300
Sprache: Deutsch	**Modulverantwortliche[r]:** Studiengangsbeauftragte/r
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester

Wiederholbarkeit:	Empfohlenes Fachsemester:
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:
Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik

Georg-August-Universität Göttingen	9 C
Modul B.Mat.2310: Optimierung	6 SWS
English title: Optimisation	

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Lernziele:	Präsenzzeit:
Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der Optimierung vertraut. Sie	84 Stunden Selbststudium: 186 Stunden

- 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.

Lehrveranstaltungen:	
1. Übungen	2 SWS
Angebotshäufigkeit: jedes Wintersemester	
2. Vorlesung (Vorlesung)	4 SWS

Prüfung: Klausur (120 Minuten)	9 C
Prüfungsvorleistungen:	
B.Mat.2310.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	

Prüfungsanforderungen:	
Nachweis der Grundkenntnisse der Optimierung	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
keine	B.Mat.0021, B.Mat.0022
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Studiengangsbeauftragte/r
Angebotshäufigkeit:	**Dauer:**
jedes Sommersemester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	4 - 6

Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:

- 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 **Modul B.Mat.3041: Overview on non-life insurance mathematics** *English title: Overview on non-life insurance mathematics*	3 C 2 SWS

Lernziele/Kompetenzen: **Learning outcome:** After completion of the module students are familiar with basic notions and methods of non-life insurance mathematics. They - are familiar with basic definitions and terms within non-life insurance mathematics; - understand central aspects of risk theory; - know substantial pricing and reserving methods; - estimate ruin probabilities. **Core skills:** After successful completion of the module students have acquired basic competencies within non-life insurance. They are able to - apply a basic inventory of solving approaches; - analyse and develop pricing models which mathematically are state of the art; - evaluate and quantify fundamental risks.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden

Lehrveranstaltung: Lecture course (Vorlesung)	2 SWS

Prüfung: Klausur (120 Minuten)	3 C

Prüfungsanforderungen: Basic knowledge on non-life insurance mathematics	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.1400
Sprache: Englisch	**Modulverantwortliche[r]:** Programme coordinator
Angebotshäufigkeit: keine Angabe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 4 - 6; Master: 1 - 4
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: **Instructor:** Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Modul B.Mat.3042: Overview on life insurance mathematics** *English title: Overview on life insurance mathematics*	3 C 2 SWS

Lernziele/Kompetenzen: **Learning outcome:** After successfully completing this module students are familiar with basic notions and methods of life insurance mathematics. In particular they • master fundamental terms and notions of life insurance mathematics; • know about risk theory and risk management; • know substantial pricing and reserving methods, in particular in health insurance; • know about legal requirements of life, health and pension insurance in Germany. **Core skills:** After successful completion of the module students have acquired basic competencies within life insurance mathematics. The student should be able to • apply a basic inventory of solving approaches; • calculate premiums and provisions in life, health and pension insurance; • evaluate and quantify fundamental risks.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden

Lehrveranstaltung: Lecture course (Vorlesung)	2 SWS

Prüfung: Klausur (120 Minuten)	3 C

Prüfungsanforderungen: Basic knowledge on life insurance mathematics	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** B.Mat.1400
Sprache: Englisch	**Modulverantwortliche[r]:** Programme coordinator
Angebotshäufigkeit: keine Angabe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** Bachelor: 4 - 6; Master: 1 - 4
Maximale Studierendenzahl: nicht begrenzt	

Bemerkungen: **Instructor:** Lecturers of the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Module B.Mat.3043: Non-life insurance mathematics**	6 C 4 WLH

| **Learning outcome, core skills:**
Non-life insurance mathematics deals with models and methods of quantifying risks with both, the occurrence of the loss and its amount showing random patterns. In particular the following problems are to be solved:

• determing appropriate insurance premiums;
• calculate adequate loss reserves;
• determine how to allocate risk between policyholder and insurer resp. insurer and reinsurers.

The German Actuarial Association (Deutsche Aktuarvereinigung e. V.) has certified this module as element of the training as an actuary („Aktuar DAV" / „Aktuarin DAV", cf. www.aktuar.de). To this end, the course is designed in view of current legislative and regulatory provisions of the Federal Republic of Germany.

Learning outcome:
The aim of the module is to equip students with knowledge in four areas:

1. risk models;
2. pricing;
3. reserving;
4. risk sharing.

After having successfully completed the module, students are familiar with fundamental terms and methods of non-life insurance mathematics. They

• are familiar with and able to handle essential definitions and terms within non-life insurance mathematics;
• have an overview of the most valuable problem statements of non-life insurance;
• understand central aspects of risk theory;
• know substantial pricing and reserving methods;
• estimate ruin probabilities;
• are acquainted with most important reinsurance forms and reinsurance pricing methods.

Core skills:
After having successfully completed the module, students have acquired fundamental competencies within non-life insurance. They are able to

• evaluate and quantify fundamental risks;
• model the aggregate loss with individual or collective model;
• apply a basic inventory of solving approaches;
• analyse and develop pricing models which mathematically are state of the art;
• apply different reserving methods and calculate outstanding losses;
• assess reinsurance contracts. | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course with exercise session	4 WLH

Examination: Written examination (120 minutes)	6 C

Examination requirements:	
Fundamental knowledge of non-life insurance mathematics	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.1400
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 4 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: External lecturers at the Institute of Mathematical Stochastics

Accreditation: By the German Actuarial Association (Deutsche Aktuarvereinigung e. V.), valid until winter semester 2017/18

Georg-August-Universität Göttingen	6 C
Module B.Mat.3044: Life insurance mathematics	4 WLH

Learning outcome, core skills:	**Workload:**
This module deals with the basics of different branches in life insurance mathematics. In particular, students get to know both the classical deterministic model and the stochastic model as well as how to apply them to problems relevant in the respective branch. On this base the students describe	Attendance time: 56 h Self-study time: 124 h

Learning outcome, core skills:

This module deals with the basics of different branches in life insurance mathematics. In particular, students get to know both the classical deterministic model and the stochastic model as well as how to apply them to problems relevant in the respective branch. On this base the students describe

- essential notions of present values;
- premiums and their present values;
- the actuarial reserve.

The German Actuarial Association (Deutsche Aktuarvereinigung e. V.) has certified this module as element of the training as an actuary („Aktuar DAV" / „Aktuarin DAV", cf. www.aktuar.de). To this end, the course is designed in view of current legislative and regulatory provisions of the Federal Republic of Germany.

Learning outcome:

After having successfully completed the module, students are familiar with fundamental terms
and methods of life insurance mathematics. In particular they

- assess cashflows in terms of financial and insurance mathematics;
- apply methods of life insurance mathematics to problems from theory and practise;
- characterise financial securities and insurance contracts in terms of cashflows;
- have an overview of the most valuable problem statements of life insurance;
- understand the stochastic interest structure;
- master fundamental terms and notions of life insurance mathematics;
- get an overwiew of most important problems in life insurance mathematics;
- understand mortality tables and leaving orders within pension insurance;
- know substantial pricing and reserving methods;
- know the economic and legal requirements of private health insurance in Germany;
- are acquainted with per-head loss statistics, present value factor calculation and biometric accounting principles.

Core skills:

After having successfully completed the module, students have acquired fundamental competencies within life insurance. They are able to

- assess cashflows with respect to both collateral and risk under deterministic interest structure;
- calculate premiums and provisions in life-, health- and pension-insurance;
- understand the actuarial equivalence principle as base of actuarial valuation in life insurance;
- apply and understand the actuarial equivalence principle for calculating premiums, actuarial reserves and ageing provisions;
- calculate profit participation in life insurance;
- master premium calculation in health insurance;

- calculate present value and settlement value of pension obligations;
- find mathematical solutions to practical questions in life, health and pension insurance.

Course: Lecture course with exercises	4 WLH

Examination: Written examination (120 minutes)	6 C

Examination requirements:	
Fundamental knowledge of life insurance mathematics	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.1400
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 4 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:
Instructor: External lecturers at the Institute of Mathematical Stochastics
Accreditation: By the German Actuarial Association (Deutsche Aktuarvereinigung e. V.), valid until summer semester 2019

Georg-August-Universität Göttingen **Module B.Mat.3111: Introduction to analytic number theory**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h Self-study time: 186 h

- solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;
- know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;
- are familiar with results and methods of prime number theory;
- acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;
- know basic sieving methods and apply them to the problems of number theory;
- know techniques used to estimate the sum of the sum of characters and of exponentials;
- analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;
- master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Analytical number theory";
- explain basic ideas of proof in the area "Analytical number theory";
- illustrate typical applications in the area "Analytical number theory".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3111.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	

Proof of knowledge and mastery of basic competencies in the area "Analytic number theory"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.1100, B.Mat.1200
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3112: Introduction to analysis of partial differential equations**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h Self-study time: 186 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with the most important types of partial differential equations and know their solutions;
- master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;
- are familiar with the theory of generalized functions and the theory of function spaces and use these for solving differential partial equations;
- apply the basic principles of functional analysis to the solution of partial different equations;
- use different theorems of function theory for solving partial different equations;
- master different asymptotic techniques to study characteristics of the solutions of partial different equations;
- are paradigmatically familiar with broader application areas of linear theory of partial different equations;
- are paradigmatically familiar with broader application areas of non-linear theory of partial different equations;
- know the importance of partial different equations in the modelling in natural and engineering sciences;
- master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Analysis of partial different equations";
- explain basic ideas of proof in the area "Analysis of partial different equations";
- illustrate typical applications in the area "Analysis of partial different equations".

Workload:
Attendance time: 84 h
Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3112.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Analysis of partial differential equations"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1100, B.Mat.1200
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3113: Introduction to differential geometry**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master the basic concepts of differential geometry; • develop a spatial sense using the examples of curves, areas and hypersurfaces; • develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability"; • master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory; • develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods; • acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems; • are able to import geometrical problems to a broader mathematical and physical context. **Core skills:** After having successfully completed the module, students will be able to • discuss basic concepts of the area "Differential geometry"; • explain basic ideas of proof in the area "Differential geometry"; • illustrate typical applications in the area "Differential geometry".	**Attendance time:** 84 h **Self-study time:** 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3113.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	
Proof of knowledge and mastery of basic competencies in the area "Differential geometry"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.1100, B.Mat.1200
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3114: Introduction to algebraic topology	6 WLH

Learning outcome, core skills: **Learning outcome:** In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students - know the basic concepts of set-theoretic topology and continuous mappings; - construct new topologies from given topologies; - know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds; - apply basic concepts of category theory to topological spaces; - use concepts of functors to obtain algebraic invariants of topological spaces and mappings; - know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them; - know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems; - calculate homology and cohomology with the aid of chain complexes; - deduce algebraic characteristics of homology and cohomology with the aid of homological algebra; - become acquainted with connections between analysis and topology; - apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds. **Core skills:** After having successfully completed the module, students will be able to - discuss basic concepts of the area "Algebraic topology"; - explain basic ideas of proof in the area "Algebraic topology"; - illustrate typical applications in the area "Algebraic topology".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH

2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3114.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Algebraic topology"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1100, B.Mat.1200
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3115: Introduction to mathematical methods in physics**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are • harmonic analysis, algebraic structures and representation theory, (group) effects; • operator algebra, C* algebra and von-Neumann algebra; • operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions; • (semi) Riemannian geometry, symplectic and Poisson geometry, quantization. One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves. **Core skills:** After having successfully completed the module, students will be able to • discuss basic concepts of the area "Mathematical methods of physics"; • explain basic ideas of proof in the area "Mathematical methods of physics"; • illustrate typical applications in the area "Mathematical methods of physics".	Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3115.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Mathematical methods in physics"	

Admission requirements:	**Recommended previous knowledge:**

none	B.Mat.1100, B.Mat.1200
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3121: Introduction to algebraic geometry**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students

are familiar with commutative algebra, also in greater detail;
know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
examine important examples like elliptic curves, Abelian varieties or algebraic groups;
use divisors for classification questions;
study algebraic curves;
prove the Riemann-Roch theorem and apply it;
use cohomological concepts and know the basics of Hodge theory;
apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
get to know connections to complex analysis and to complex geometry.
Core skills:

After having successfully completed the module, students will be able to

discuss basic concepts of the area "Algebraic geometry"; explain basic ideas of proof in the area "Algebraic geometry"; illustrate typical applications in the area "Algebraic geometry". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes)	9 C

Examination prerequisites:

B.Mat.3121.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions

Examination requirements:

Proof of knowledge and mastery of basic competencies in the area "Algebraic geometry"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.1100, B.Mat.1200
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3122: Introduction to algebraic number theory**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students • know Noetherian and Dedekind rings and the class groups; • are familiar with discriminants, differents and bifurcation theory of Hilbert; • know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL); • are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues; • know densities, the Tchebotarew theorem and applications; • work with orders, S-integers and S-units; • know the class field theory of Hilbert, Takagi and Idele theoretical field theory; • are familiar with Zp-extensions and their Iwasawa theory; • discuss the most important hypotheses of Iwasawa theory and their consequences. Concerning algorithmic aspects of number theory, the following competencies are pursued. Students • work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors; • are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests; • use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics; • discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields; • calculate class groups and fundamental units; • calculate Galois groups of absolute number fields. **Core skills:** After having successfully completed the module, students will be able to • discuss basic concepts of the area "Algebraic number theory"; • explain basic ideas of proof in the area "Algebraic number theory"; • illustrate typical applications in the area "Algebraic number theory".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3122.Ue:Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Algebraic number theory"	

Admission requirements: none	Recommended previous knowledge: B.Mat.1100, B.Mat.1200
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen Module B.Mat.3123: Introduction to algebraic structures	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students	**Workload:** Attendance time: 84 h Self-study time: 186 h

- know basic concepts like rings, modules, algebras and Lie algebras;
- know important examples of Lie algebras and algebras;
- know special classes of Lie groups and their special characteristics;
- know classification theorems for finite-dimensional algebras;
- apply basic concepts of category theory to algebras and modules;
- know group actions and their basic classifications;
- apply the enveloping algebra of Lie algebras;
- apply ring and module theory to basic constructs of algebraic geometry;
- use combinatorial tools for the study of associative algebras and Lie algebras;
- acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups;
- know Hopf algebras as well as their deformation and representation theory.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Algebraic structures";
- explain basic ideas of proof in the area "Algebraic structures";
- illustrate typical applications in the area "Algebraic structures".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:**	9 C

B.Mat.3123.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements:

Proof of knowledge and mastery of basic competencies in the area "Algebraic structures"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.1100, B.Mat.1200
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3124: Introduction to groups, geometry and dynamical systems**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Groups, geometry and dynamical systems" students get to know the most important classes of groups as well as the algebraic, geometrical and analytical tools that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Group theory uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of the area "Groups, geometry and dynamical systems" that supplement one another complementarily. The following content-related competencies are pursued. Students

• know basic concepts of groups and group homomorphisms;
• know important examples of groups;
• know special classes of groups and their special characteristics;
• apply basic concepts of category theory to groups and define spaces via universal properties;
• apply the concepts of functors to obtain algebraic invariants;
• know group actions and their basic classification results;
• know the basics of group cohomology and compute these for important examples;
• know the basics of geometrical group theory like growth characteristics;
• know self-similar groups, their basic constructs as well as examples with interesting characteristics;
• use geometrical and combinatorial tools for the study of groups;
• know the basics of the representation theory of compact Lie groups.

Core skills:

After having successfully completed the module, students will be able to

• discuss basic concepts of the area "Groups, geometry and dynamical systems";
• explain basic ideas of proof in the area "Groups, geometry and dynamical systems";
• illustrate typical applications in the area "Groups, geometry and dynamical systems". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes)	9 C
Examination prerequisites: B.Mat.3124.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Groups, geometry and dynamical systems"	

Admission requirements: none	Recommended previous knowledge: B.Mat.1100, B.Mat.1200
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3125: Introduction to non-commutative geometry**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** In the modules of the cycle "Non-commutative geometry" students get to know the conception of space of non-commutative geometry and some of its applications in geometry, topology, mathematical physics, the theory of dynamical systems and number theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued. Students • are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory; • construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains; • know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it; • know important examples of simple C*-algebras and deduce their basic characteristics; • apply basic concepts of category theory to C*-algebras; • model the symmetries of non-commutative spaces; • apply Hilbert modules in C*-algebras; • know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it; • apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales; • compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them; • classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations; • classify W*-algebras and know the intrinsic dynamic of factors; • apply von Neumann algebras to the axiomatic formulation of quantum field theory; • use von Neumann algebras for the construction of L2 invariants for manifolds and groups; • understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups; • define the invariants of algebras and modules with chain complexes and their homology and calculate these;	**Workload:** Attendance time: 84 h Self-study time: 186 h

- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Non-commutative geometry";
- explain basic ideas of proof in the area "Non-commutative geometry";
- illustrate typical applications in the area "Non-commutative geometry".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3125.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Non-commutative geometry"	

Admission requirements: none	Recommended previous knowledge: B.Mat.1100, B.Mat.1200
Language: English	Person responsible for module: Programme coordinator
Course frequency: not specified	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen Module B.Mat.3131: Introduction to inverse problems	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h Self-study time: 186 h

- are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;
- evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors;
- analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;
- analyse the convergence of regularisation methods with the help of complex analysis;
- analyse regularisation methods from stochastic error models;
- apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;
- model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region;
- analyse the uniqueness and conditional stability of inverse problems of partial differential equations;
- deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;
- formulate mathematical models of medical imaging like computed tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Inverse problems";
- explain basic ideas of proof in the area "Inverse problems";
- illustrate typical applications in the area "Inverse problems".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes)	9 C
Examination prerequisites: B.Mat.3131.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

| **Examination requirements:**
Proof of knowledge and mastery of basic competencies in the area "Inverse problems" | |

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1300
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

| **Georg-August-Universität Göttingen** | 9 C |
| **Module B.Mat.3132: Introduction to approximation methods** | 6 WLH |

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	84 h
The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 186 h

- are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;
- can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;
- know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions;
- acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;
- apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
- evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;
- are informed about current developments of efficient data approximation and data analysis;
- adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Approximation methods";
- explain basic ideas of proof in the area "Approximation methods" for one- and multidimensional data;
- illustrate typical applications in the area of data approximation and data analysis.

| **Courses:** | |
| **1. Lecture course** (Lecture) | 4 WLH |

2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3132.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Approximation methods"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1300
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
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 B.Mat.3133: Introduction to numerics of partial differential equations**	9 C 6 WLH

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

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution;
- know the basics of the theory of linear integral equations;
- are familiar with basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM);
- analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;
- apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;
- know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;
- apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems;
- apply available software for the solution of partial differential equations and evaluate the results sceptically;
- evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations;
- know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Numerics of partial differential equations";
- explain basic ideas of proof in the area "Numerics of partial differential equations";
- illustrate typical applications in the area "Numerics of partial differential equations".

Workload:

Attendance time:
84 h
Self-study time:
186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3133.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Numerics of partial differential equations"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.1300
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
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 B.Mat.3134: Introduction to optimisation**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;
• evaluate the existence and uniqueness of the solution of an optimisation problem;
• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;
• know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised;
• analyse the complexity of an optimisation problem;
• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;
• develop optimisation methods and adapt general methods to special problems;
• deduce upper and lower bounds for optimisation problems and understand their meaning;
• understand the geometrical structure of an optimisation problem and apply it for solution strategies;
• distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times;
• acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation;
• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;
• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.

Core skills:

After having successfully completed the module, students will be able to

• discuss basic concepts of the area "Optimisation";
• explain basic ideas of proof in the area "Optimisation";
• illustrate typical applications in the area "Optimisation". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes)	9 C
Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3134.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	
Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Optimisation"	

Admission requirements: none	Recommended previous knowledge: B.Mat.1300
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
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 B.Mat.3137: Introduction to variational analysis**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in variational analysis and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems; - master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems; - understand basic concepts of the convergence of sets and continuity of set-valued functions; - understand basic concepts of variational geometry; - calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions; - understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals; - analyse constrained and parametric optimisation problems with the help of duality theory; - calculate and use the Legendre-Fenchel transformation and infimal convulutions; - formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis; - apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria; - understand the connection between convex functions and monotone operators; - examine the convergence of fixed point iterations with the help of the theory of monotone operators; - deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence; - apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems; - model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations; - know applications of control theory and apply methods of dynamic programming; - use tools of variational analysis in image processing and with inverse problems; - know basic concepts and methods of stochastic optimisation. **Core skills:**	**Workload:** Attendance time: 84 h Self-study time: 186 h

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Variational analysis";
- explain basic ideas of proof in the area "Variational analysis";
- illustrate typical applications in the area "Variational analysis".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) (120 minutes) **Examination prerequisites:** B.Mat.3137.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Variational analysis"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1300
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3138: Introduction to image and geometry processing	6 WLH

Learning outcome, core skills:	Workload:

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;
- learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;
- learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;
- learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;
- acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;
- know basic concepts and methods of topology;
- are familiar with visualisation software;
- apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
- know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;
- evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;
- are informed about current developments of efficient geometrical and topological data analysis;
- adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Image and geometry processing";
- explain basic ideas of proof in the area "Image and geometry processing";
- illustrate typical applications in the area "Image and geometry processing".

Workload:
Attendance time:
84 h
Self-study time:
186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3138.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Image and geometry processing"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1300
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
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 B.Mat.3139: Introduction to scientific computing / applied mathematics**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Scientific computing / applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / Applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;
• know basic methods for the numerical solution of these models;
• analyse stability, convergence and efficiency of numerical solution strategies;
• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;
• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;
• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.

Core skills:

After having successfully completed the module, students will be able to

• discuss basic concepts of the area "Scientific computing / applied mathematics";
• explain basic ideas of proof in the area "Scientific computing / applied mathematics";
• illustrate typical applications in the area "Scientific computing / applied mathematics". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses: **1. Lecture course** (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3139.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	

Proof of knowledge and mastery of basic competencies in the area "Scientific computing / applied mathematics"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.1300
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: Lecturers at the Institute of Numerical and Applied Mathematics

Georg-August-Universität Göttingen	9 C
Module B.Mat.3141: Introduction to applied and mathematical stochastics	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students	Self-study time: 186 h

- are familiar with advanced concepts of probability theory established on measure theory and apply them independently;
- are familiar with substantial concepts and approaches of probability modelling and inferential statistics;
- know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;
- have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;
- understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;
- analyse the convergence characteristic of stochastic processes;
- analyse regularity characteristics of the paths of stochastic processes;
- adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;
- analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed;
- discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Applied and mathematical stochastics";
- explain basic ideas of proof in the area "Applied and mathematical stochastics";
- illustrate typical applications in the area "Applied and mathematical stochastics".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes)	9 C
Examination prerequisites: B.Mat.3141.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Applied and mathematical stochastics"	

Admission requirements: none	Recommended previous knowledge: B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3142: Introduction to stochastic processes**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with advanced concepts of probability theory established on measure theory and apply them independently; • know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces; • understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes; • know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes; • analyse regularity characteristics of the paths of stochastic processes; • construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics; • are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms; • analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems; • formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics; • are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes; • know fundamental convergence theorems for stochastic processes and generalise these; • model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes; • analyse models in mathematical economics and finance and understand evaluation methods for financial products. **Core skills:** After having successfully completed the module, students will be able to • discuss basic concepts of the area "Stochastic processes";	**Workload:** Attendance time: 84 h Self-study time: 186 h

- explain basic ideas of proof in the area "Stochastic processes";
- illustrate typical applications in the area "Stochastic processes".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3142.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Stochastic processes"	

Admission requirements: none	Recommended previous knowledge: B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3143: Introduction to stochastic methods of economathematics**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master problems, basic concepts and stochastic methods of economathematics; • understand stochastic connections; • understand references to other mathematical areas; • get to know possible applications in theory and practice; • gain insight into the connection of mathematics and economic sciences. **Core skills:** After having successfully completed the module, students will be able to • discuss basic concepts of the area "Stochastic methods of economathematics"; • explain basic ideas of proof in the area "Stochastic methods of economathematics"; • illustrate typical applications in the area "Stochastic methods of economathematics".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3143.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Stochastic methods of economathematics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator

Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3144: Introduction to mathematical statistics	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	84 h
The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 186 h
- are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics; - evaluate statistical methods mathematically precisely via suitable risk and loss concepts; - analyse optimality characteristics of statistical estimate methods via lower and upper bounds; - analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory; - are familiar with basic statistical distribution models that base on the theory of exponential indexed families; - know different techniques to obtain lower and upper risk bounds in these models; - are confident in modelling typical data structures of regression; - analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand; - are able to mathematically analyse resampling methods and apply them purposively; - are familiar with advanced tools of non-parametric statistics and empirical process theory; - independently become acquainted with a current topic of mathematical statistics; - evaluate complex statistical methods and enhance them in a problem-oriented way.	
Core skills:	
After having successfully completed the module, students will be able to	
- discuss basic concepts of the area "Mathematical statistics"; - explain basic ideas of proof in the area "Mathematical statistics"; - illustrate typical applications in the area "Mathematical statistics".	

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3144.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Mathematical statistics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3145: Introduction to statistical modelling and inference**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Statistical modelling and inference" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation; • are familiar with the tools of asymptotic statistical inference; • learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods; • are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties; • become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.; • are able to develop and mathematically evaluate complex statistical models for real data problems. **Core skills:** After having successfully completed the module, students will be able to • discuss basic concepts of the area "Statistical modelling and inference"; • explain basic ideas of proof in the area "Statistical modelling and inference"; • illustrate typical applications in the area "Statistical modelling and inference".	Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, oral examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3145.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Statistical modelling and inference"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.1400
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3146: Introduction to multivariate statistics	6 WLH

	Workload:
Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	84 h
The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 186 h

- are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications;
- can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;
- are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;
- are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;
- are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;
- analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;
- are confident to apply resampling methods to non-Euclidean descriptors;
- are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;
- have a fundamental knowledge of statistics of point processes and Bayesian methods involved;
- are familiar with concepts of large scale computational statistical techniques;
- independently become acquainted with a current topic of multivariate and non-Euclidean statistics;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- discuss basic concepts of the area "Multivariate statistics";
- explain basic ideas of proof in the area "Multivariate statistics";
- illustrate typical applications in the area "Multivariate statistics".

Courses:	
1. Lecture course (Lecture)	4 WLH

2. Exercise session (Exercise)	2 WLH

Examination: Written or oral exam, written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3146.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Multivariate statistics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3147: Introduction to statistical foundations of data science**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in the area of "Statistical foundations of data science". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications; - evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts; - analyse characteristics of statistical estimation methods via lower and upper information bounds; - are familiar with basic statistical distribution models that base on the theory of exponential families; - are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies - analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand; - are able to mathematically analyse resampling methods and apply them purposively; - are familiar with concepts of large scale computational statistical techniques; - are familiar with advanced tools of non-parametric statistics and empirical process theory; - independently become acquainted with a current topic of statistical data science; - evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to - discuss basic concepts of the area "Statistical foundations of data science"; - explain basic ideas of proof in the area "Statistical foundations of data science"; - illustrate typical applications in the area "Statistical foundations of data science".	Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: written examination (120 minutes) or oral examination (appr. 20 minutes) **Examination prerequisites:** B.Mat.3147.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of knowledge and mastery of basic competencies in the area "Statistical foundations of data science"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 5 - 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3311: Advances in analytic number theory	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h Self-study time: 186 h
- solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods; - know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory; - are familiar with results and methods of prime number theory; - acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory; - know basic sieving methods and apply them to the problems of number theory; - know techniques used to estimate the sum of the sum of characters and of exponentials; - analyse the distribution of rational points on suitable algebraic varieties using analytical techniques; - master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.	
Core skills:	
After having successfully completed the module, students will be able to	
- handle methods and concepts of the area "Analytic number theory" confidently; - explain complex issues of the area "Analytic number theory"; - apply methods of the area "Analytic number theory" to new problems in this area.	

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3311.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Analytic number theory"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3111
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3111 "Introduction to analytic number theory"	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3312: Advances in analysis of partial differential equations**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h Self-study time: 186 h
The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the most important types of partial differential equations and know their solutions; • master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations; • are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations; • apply the basic principles of functional analysis to the solution of partial different equations; • use different theorems of function theory for solving partial different equations; • master different asymptotic techniques to study characteristics of the solutions of partial different equations; • are paradigmatically familiar with broader application areas of linear theory of partial different equations; • are paradigmatically familiar with broader application areas of non-linear theory of partial different equations; • know the importance of partial different equations in the modelling in natural and engineering sciences; • master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis. **Core skills:** After having successfully completed the module, students will be able to • handle methods and concepts of the area "Analysis of partial differential equations" confidently; • explain complex issues of the area "Analysis of partial differential equations"; • apply methods of the area "Analysis of partial differential equations" to new problems in this area.	

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) Examination prerequisites: B.Mat.3312.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Analysis of partial differential equations"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3112
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3112 "Introduction to analysis of partial differential equations"	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3313: Advances in differential geometry**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• master the basic concepts of differential geometry;
• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;
• develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability";
• master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory;
• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;
• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;
• are able to import geometrical problems to a broader mathematical and physical context.

Core skills:

After having successfully completed the module, students will be able to

• handle methods and concepts of the area "Differential geometry" confidently;
• explain complex issues of the area "Differential geometry";
• apply methods of the area "Differential geometry" to new problems in this area. | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3313.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	

Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Differential geometry"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3113
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3113 "Introduction to differential geometry"	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3314: Advances in algebraic topology**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students

• know the basic concepts of set-theoretic topology and continuous mappings;
• construct new topologies from given topologies;
• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;
• apply basic concepts of category theory to topological spaces;
• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;
• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;
• know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems;
• calculate homology and cohomology with the aid of chain complexes;
• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;
• become acquainted with connections between analysis and topology;
• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.

Core skills:

After having successfully completed the module, students will be able to

• handle methods and concepts of the area "Algebraic topology" confidently;
• explain complex issues of the area "Algebraic topology";
• apply methods of the area "Algebraic topology" to new problems in this area. | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses: **1. Lecture course** (Lecture)	4 WLH

2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3314.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic topology"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3114
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3114 "Introduction to algebraic topology"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module B.Mat.3315: Advances in mathematical methods in physics	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	Self-study time: 186 h

The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are

- harmonic analysis, algebraic structures and representation theory, (group) effects;
- operator algebra, C* algebra and von-Neumann algebra;
- operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;
- (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.

One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Mathematical methods in physics" confidently;
- explain complex issues of the area "Mathematical methods in physics";
- apply methods of the area "Mathematical methods in physics" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites: B.Mat.3315.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Mathematical methods in physics"	

Admission requirements:	**Recommended previous knowledge:**

none	B.Mat.3115
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: on an irregular basis	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3321: Advances in algebraic geometry**	9 C 6 WLH

Learning outcome, core skills:
Learning outcome:
 	
In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.
 	
Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students
 	
  • are familiar with commutative algebra, also in greater detail;
  • know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
  • examine important examples like elliptic curves, Abelian varieties or algebraic groups;
  • use divisors for classification questions;
  • study algebraic curves;
  • prove the Riemann-Roch theorem and apply it;
  • use cohomological concepts and know the basics of Hodge theory;
  • apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
  • classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
  • get to know connections to complex analysis and to complex geometry.
 	
Core skills:
 	
After having successfully completed the module, students will be able to
 	
  • handle methods and concepts of the area "Algebraic geometry" confidently;
  • explain complex issues of the area "Algebraic geometry";
  • apply methods of the area "Algebraic geometry" to new problems in this area.
	Workload:
	Attendance time:
	84 h
	Self-study time:
	186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:**	9 C

B.Mat.3321.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic geometry"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3121
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3121 "Introduction to algebraic geometry"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3322: Advances in algebraic number theory**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students	**Workload:** Attendance time: 84 h Self-study time: 186 h

- know Noetherian and Dedekind rings and the class groups;
- are familiar with discriminants, differents and bifurcation theory of Hilbert;
- know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL);
- are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;
- know densities, the Tchebotarew theorem and applications;
- work with orders, S-integers and S-units;
- know the class field theory of Hilbert, Takagi and Idele theoretical field theory;
- are familiar with Zp-extensions and their Iwasawa theory;
- discuss the most important hypotheses of Iwasawa theory and their consequences.

Concerning algorithmic aspects of number theory, the following competencies are pursued. Students

- work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;
- are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests;
- use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;
- discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;
- calculate class groups and fundamental units;
- calculate Galois groups of absolute number fields.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Algebraic number theory" confidently;
- explain complex issues of the area "Algebraic number theory";
- apply methods of the area "Algebraic number theory" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3322.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessionsungen	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic number theory"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3122
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3122 "Introduction to algebraic number theory"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module B.Mat.3323: Advances in algebraic structures	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
	Self-study time: 186 h

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students

- know basic concepts like rings, modules, algebras and Lie algebras;
- know important examples of Lie algebras and algebras;
- know special classes of Lie groups and their special characteristics;
- know classification theorems for finite-dimensional algebras;
- apply basic concepts of category theory to algebras and modules;
- know group actions and their basic classifications;
- apply the enveloping algebra of Lie algebras;
- apply ring and module theory to basic constructs of algebraic geometry;
- use combinatorial tools for the study of associative algebras and Lie algebras;
- acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups;
- know Hopf algebras as well as their deformation and representation theory.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Algebraic structures" confidently;
- explain complex issues of the area "Algebraic structures";
- apply methods of the area "Algebraic structures" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites:	

B.Mat.3323.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic structures"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3123
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3123 "Introduction to algebraic structures"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module B.Mat.3324: Advances in groups, geometry and dynamical systems**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: In the modules of the cycle "Groups, geometry and dynamical systems" students get to know the most important classes of groups as well as the algebraic, geometrical and analytical tools that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Group theory uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of the area "Groups, geometry and dynamical systems" that supplement one another complementarily. The following content-related competencies are pursued. Students • know basic concepts of groups and group homomorphisms; • know important examples of groups; • know special classes of groups and their special characteristics; • apply basic concepts of category theory to groups and define spaces via universal properties; • apply the concepts of functors to obtain algebraic invariants; • know group actions and their basic classification results; • know the basics of group cohomology and compute these for important examples; • know the basics of geometrical group theory like growth characteristics; • know self-similar groups, their basic constructs as well as examples with interesting characteristics; • use geometrical and combinatorial tools for the study of groups; • know the basics of the representation theory of compact Lie groups. **Core skills:** After having successfully completed the module, students will be able to • handle methods and concepts of the area "Groups, geometry and dynamical systems" confidently; • explain complex issues of the area "Groups, geometry and dynamical systems"; • apply methods of the area "Groups, geometry and dynamical systems" to new problems in this area.	Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites:	
B.Mat.3324.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements:	
Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Groups, geometry and dynamical systems"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3124
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3124 "Introduction to groups, geometry and dynamical systems"	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3325: Advances in non-commutative geometry**	9 C 6 WLH

| **Learning outcome, core skills:**

 Learning outcome:

 In the modules of the cycle "Non-commutative geometry" students get to know the conception of space of non-commutative geometry and some of its applications in geometry, topology, mathematical physics, the theory of dynamical systems and number theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

 Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued. Students

 • are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;
 • construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;
 • know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it;
 • know important examples of simple C*-algebras and deduce their basic characteristics;
 • apply basic concepts of category theory to C*-algebras;
 • model the symmetries of non-commutative spaces;
 • apply Hilbert modules in C*-algebras;
 • know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it;
 • apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;
 • compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;
 • classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;
 • classify W*-algebras and know the intrinsic dynamic of factors;
 • apply von Neumann algebras to the axiomatic formulation of quantum field theory;
 • use von Neumann algebras for the construction of L2 invariants for manifolds and groups;
 • understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups;
 • define the invariants of algebras and modules with chain complexes and their homology and calculate these; | **Workload:**
 Attendance time:
 84 h
 Self-study time:
 186 h |

- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Non-commutative geometry" confidently;
- explain complex issues of the area "Non-commutative geometry";
- apply methods of the area "Non-commutative geometry" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3325.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Non-commutative geometry"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3125
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3125 "Introduction to non-commutative geometry"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module B.Mat.3331: Advances in inverse problems	6 WLH

	Workload:
Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
	Self-study time: 186 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;
- evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors;
- analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;
- analyse the convergence of regularisation methods with the help of complex analysis;
- analyse regularisation methods from stochastic error models;
- apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;
- model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region;
- analyse the uniqueness and conditional stability of inverse problems of partial differential equations;
- deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;
- formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Inverse problems" confidently;
- explain complex issues of the area "Inverse problems";
- apply methods of the area "Inverse problems" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) Examination prerequisites: B.Mat.3331.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Inverse problems"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3131
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3131 "Introduction to inverse problems"	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Bachelor: 6; Master: 1 - 4
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 B.Mat.3332: Advances in approximation methods**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;
• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;
• know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions;
• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;
• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
• evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time;
• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;
• are informed about current developments of efficient data approximation and data analysis;
• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.

Core skills:

After having successfully completed the module, students will be able to

• handle methods and concepts of the area "Approximation methods" confidently;
• explain complex issues of the area "Approximation methods";
• apply methods of the area "Approximation methods" to new problems in this area. | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) Examination prerequisites: B.Mat.3332.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Approximation methods"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3132
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3132 "Introduction to approximation methods"	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Bachelor: 6; Master: 1 - 4
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 B.Mat.3333: Advances in numerics of partial differential equations**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	**Workload:** Attendance time: 84 h Self-study time: 186 h

- are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution;
- know the basics of the theory of linear integral equations;
- are familiar with basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM);
- analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;
- apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;
- know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;
- apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems;
- apply available software for the solution of partial differential equations and evaluate the results sceptically;
- evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations;
- know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Numerics of partial differential equations" confidently;
- explain complex issues of the area "Numerics of partial differential equations";

- apply methods of the area "Numerics of partial differential equations" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3333.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Numerics of partial differential equations"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3133
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3133 "Introduction to numerics of partial differential equations"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3334: Advances in optimisation	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	84 h
The successful completion of modules of the cycle "Optimisation" enables students to	Self-study time:
learn methods, concepts, theories and applications in the area of "Optimisation", so the	186 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;
- evaluate the existence and uniqueness of the solution of an optimisation problem;
- identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;
- know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised;
- analyse the complexity of an optimisation problem;
- classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;
- develop optimisation methods and adapt general methods to special problems;
- deduce upper and lower bounds for optimisation problems and understand their meaning;
- understand the geometrical structure of an optimisation problem and apply it for solution strategies;
- distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times;
- acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation;
- acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;
- handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Optimisation" confidently;
- explain complex issues of the area "Optimisation";
- apply methods of the area "Optimisation" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3334.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Optimisation"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3134
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3134 "Introduction to optimisation"	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3337: Advances in variational analysis	6 WLH

Learning outcome, core skills:	Workload:

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in the area of "Variational analysis" and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;
- master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems;
- understand basic concepts of the convergence of sets and continuity of set-valued functions;
- understand basic concepts of variational geometry;
- calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;
- understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;
- analyse constrained and parametric optimisation problems with the help of duality theory;
- calculate and use the Legendre-Fenchel transformation and infimal convulutions;
- formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;
- apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;
- understand the connection between convex functions and monotone operators;
- examine the convergence of fixed point iterations with the help of the theory of monotone operators;
- deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;
- apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;
- model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;
- know applications of control theory and apply methods of dynamic programming;
- use tools of variational analysis in image processing and with inverse problems;
- know basic concepts and methods of stochastic optimisation.

Core skills:

Workload:
Attendance time:
84 h
Self-study time:
186 h

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Variational analysis" confidently;
- explain complex issues of the area "Variational analysis";
- apply methods of the area "Variational analysis" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3337.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Variational analysis"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3137
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3137 "Introduction in variational analysis"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
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 B.Mat.3338: Advances in image and geometry processing**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces; - learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces; - learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform; - learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces; - acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies; - know basic concepts and methods of topology; - are familiar with visualisation software; - apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; - know which special characteristics of an image or of a geometry can be extracted and worked on with which methods; - evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time; - acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data; - are informed about current developments of efficient geometrical and topological data analysis; - adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data. **Core skills:** After having successfully completed the module, students will be able to - handle methods and concepts of the area "Image and geometry processing" confidently; - explain complex issues of the area "Image and geometry processing";	**Workload:** Attendance time: 84 h Self-study time: 186 h

- apply methods of the area "Image and geometry processing" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3338.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Image and geometry processing"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3138
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3138 "Introduction to image and geometry processing"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
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 B.Mat.3339: Advances in scientific computing / applied mathematics**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:**	**Workload:**
The successful completion of modules of the cycle "Scientific computing / Applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / Applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions; • know basic methods for the numerical solution of these models; • analyse stability, convergence and efficiency of numerical solution strategies; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware; • use methods of scientific computing for solving application problems, like e. g. of natural and business sciences. **Core skills:** After having successfully completed the module, students will be able to • handle methods and concepts of the area "Scientific computing / applied mathematics" confidently; • explain complex issues of the area "Scientific computing / applied mathematics"; • apply methods of the area "Scientific computing / applied mathematics" to new problems in this area.	Attendance time: 84 h Self-study time: 186 h

Courses: **1. Lecture course** (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3339.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	

Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Scientific computing / applied mathematics"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3139
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3139 "Introduction to scientific computing / applied mathematics"	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3341: Advances in applied and mathematical stochastics	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
	Self-study time: 186 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students

- are familiar with advanced concepts of probability theory established on measure theory and apply them independently;
- are familiar with substantial concepts and approaches of probability modelling and inferential statistics;
- know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;
- have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;
- understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;
- analyse the convergence characteristic of stochastic processes;
- analyse regularity characteristics of the paths of stochastic processes;
- adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;
- analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed;
- discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Applied and mathematical stochastics" confidently;
- explain complex issues of the area "Applied and mathematical stochastics";
- apply methods of the area "Applied and mathematical stochastics" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3341.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Applied and mathematical stochastics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3141
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3141 "Introduction to applied and mathematical stochastics"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen Module B.Mat.3342: Advances in stochastic processes	9 C 6 WLH

| **Learning outcome, core skills:** **Learning outcome:** The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students are familiar with advanced concepts of probability theory established on measure theory and apply them independently; know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces; understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes; know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes; analyse regularity characteristics of the paths of stochastic processes; construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics; are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms; analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems; formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics; are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes; know fundamental convergence theorems for stochastic processes and generalise these; model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes; analyse models in mathematical economics and finance and understand evaluation methods for financial products. **Core skills:** After having successfully completed the module, students will be able to handle methods and concepts of the area "Stochastic processes" confidently; | **Workload:** Attendance time: 84 h Self-study time: 186 h |

- explain complex issues of the area "Stochastic processes";
- apply methods of the area "Stochastic processes" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3342.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Stochastic processes"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3142
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3142 "Introduction to stochastic processes"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3343: Advances in stochastic methods of economathematics	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h
	Self-study time:
	186 h
• master problems, basic concepts and stochastic methods of economathematics;	
• understand stochastic connections;	
• understand references to other mathematical areas;	
• get to know possible applications in theory and practice;	
• gain insight into the connection of mathematics and economic sciences.	
Core skills:	
After having successfully completed the module, students will be able to	
• handle methods and concepts of the area "Stochastic methods of economathematics" confidently;	
• explain complex issues of the area "Stochastic methods of economathematics";	
• apply methods of the area "Stochastic methods of economathematics" to new problems in this area.	

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites:	
B.Mat.3343.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements:	
Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Stochastic methods of economathematics"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3143

Language:	**Person responsible for module:**
English	Programme coordinator

Course frequency:	**Duration:**

Usually subsequent to the module B.Mat.3143 "Introduction to stochastic methods of economathematics"	1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3344: Advances in mathematical statistics**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics; • evaluate statistical methods mathematically precisely via suitable risk and loss concepts; • analyse optimality characteristics of statistical estimate methods via lower and upper bounds; • analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory; • are familiar with basic statistical distribution models that base on the theory of exponential indexed families; • know different techniques to obtain lower and upper risk bounds in these models; • are confident in modelling typical data structures of regression; • analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand; • are able to mathematically analyse resampling methods and apply them purposively; • are familiar with advanced tools of non-parametric statistics and empirical process theory; • independently become acquainted with a current topic of mathematical statistics; • evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to • handle methods and concepts of the area "Mathematical statistics" confidently; • explain complex issues of the area "Mathematical statistics"; • apply methods of the area "Mathematical statistics" to new problems in this area	**Workload:** Attendance time: 84 h Self-study time: 186 h
Courses: **1. Lecture course** (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) Examination prerequisites: B.Mat.3344.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Mathematical statistics"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3144
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3144 "Introduction to mathematical statistics"	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Module B.Mat.3345: Advances in statistical modelling and inference	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	84 h
The successful completion of modules of the cycle "Statistical modelling and inference"	Self-study time:
enables students to learn methods, concepts, theories and applications in this area.	186 h
During the course of the cycle students will be successively introduced to current	
research topics and able to carry out independent contributions to research (e. g. within	
the scope of a Master's thesis). Depending on the current course offer the following	
content-related competencies may be pursued. Students	

- are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation;
- are familiar with the tools of asymptotic statistical inference;
- learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;
- are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;
- become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;
- are able to develop and mathematically evaluate complex statistical models for real data problems.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Statistical modelling and inference" confidently;
- explain complex issues of the area "Statistical modelling and inference";
- apply methods of the area "Statistical modelling and inference" to new problems in this area.

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites:	
B.Mat.3345.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements:	
Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Statistical modelling and inference"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3145
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3111 "Introduction to statistical modelling and inference"	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 6; Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module B.Mat.3346: Advances in multivariate statistics**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	**Workload:** Attendance time: 84 h Self-study time: 186 h

- are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications;
- can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;
- are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;
- are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;
- are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;
- analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;
- are confident to apply resampling methods to non-Euclidean descriptors;
- are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;
- have a fundamental knowledge of statistics of point processes and Bayesian methods involved;
- are familiar with concepts of large scale computational statistical techniques;
- independently become acquainted with a current topic of multivariate and non-Euclidean statistics;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area "Multivariate statistics" confidently;
- explain complex issues of the area "Multivariate statistics";
- apply methods of the area "Multivariate statistics" to new problems in this area.

Courses: **1. Lecture course** (Lecture)	4 WLH

2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3346.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Multivariate statistics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3146
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3146 "Introduction to multivariate statistics"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

| Georg-August-Universität Göttingen | 9 C |
| Module B.Mat.3347: Advances in statistical foundations of data science | 6 WLH |

Learning outcome, core skills:	Workload:

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle ""Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications;
- evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;
- analyse characteristics of statistical estimation methods via lower and upper information bounds;
- are familiar with basic statistical distribution models that base on the theory of exponential families;
- are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies
- analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand;
- are able to mathematically analyse resampling methods and apply them purposively;
- are familiar with concepts of large scale computational statistical techniques;
- are familiar with advanced tools of non-parametric statistics and empirical process theory;
- independently become acquainted with a current topic of statistical data science;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- handle methods and concepts of the area ""Statistical foundations of data science" confidently;
- explain complex issues of the area ""Statistical foundations of data sciencee";
- apply methods of the area ""Statistical foundations of data science" to new problems in this area.

Workload:

Attendance time:
84 h
Self-study time:
186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** B.Mat.3347.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Statistical foundations of data science"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3147
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3147 "Introduction to statistical foundations of data science"	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Bachelor: 6; Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Modul B.Phi.01: Basismodul Theoretische Philosophie	4 SWS
English title: Basic Studies in Theoretical Philosophy	

Lernziele/Kompetenzen:	Arbeitsaufwand:
1. In einem Einführungskurs (Vorlesung oder Einführungsseminar) erwerben die Studierenden Kenntnis zentraler Themen, Grundbegriffe und Theorieansätze der Theoretischen Philosophie in ihren Disziplinen Erkenntnistheorie, Wissenschaftsphilosophie, Sprachphilosophie oder Metaphysik.	Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden
2. In einem Proseminar erlangen die Studierenden grundlegende Fähigkeiten, sich mit Sachfragen der theoretischen Philosophie begrifflich präzise und argumentativ auseinanderzusetzen, insbesondere: ausgewählte Problembereiche und systematische Überlegungen der theoretischen Philosophie adäquat darzustellen, Argumentationen zu analysieren und auf elementarem Niveau in mündlicher und schriftlicher Form zu diskutieren.	

Lehrveranstaltungen:	
1. Einführungskurs in die theoretische Philosophie (Vorlesung, Seminar)	2 SWS
2. Proseminar zur theoretischen Philosophie	2 SWS
Es muss <u>eine</u> der nachfolgenden Prüfungsformen (Klausur, Hausarbeit oder Essays) absolviert werden.	
Angebotshäufigkeit: Einführungskurs bevorzugt im Wintersemester	

Prüfung: Hausarbeit (max. 15 Seiten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfung: Essay (max. 15 Seiten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfungsanforderungen: Verständnis zentraler Begriffe, Probleme und Theorieansätze der theoretischen Philosophie. Darstellung und Diskussion von Themen der theoretischen Philosophie auf elementarem Niveau in schriftlicher Form. Die Prüfung wird in einem Proseminar (nicht in der Einführungsvorlesung oder dem Einführungsseminar!) abgelegt.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Christian Beyer
Angebotshäufigkeit: jedes Semester; Einführungskurs bevorzugt im Wintersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 3
Maximale Studierendenzahl: 100	

Georg-August-Universität Göttingen **Modul B.Phi.02: Basismodul Praktische Philosophie** *English title: Basic Studies in Practical Philosophy*	9 C 4 SWS

| **Lernziele/Kompetenzen:**
 1. In einem Einführungskurs (Vorlesung oder Einführungsseminar) erwerben die Studierenden Kenntnis zentraler Probleme, Grundbegriffe und Theorieansätze der Praktischen Philosophie. Sie überschauen die Teilgebiete, kennen typische Themen und Terminologien sowie einige der wichtigsten Theorieansätze in Grundzügen.

 2. In einem Proseminar (Basisseminar) erlangen die Studierenden grundlegende Fähigkeiten, sich mit Sachfragen der Praktischen Philosophie begrifflich präzise und argumentativ auseinander zu setzen, insbesondere: Grundprobleme und -positionen adäquat darzustellen, ethische Argumentationen zu analysieren und auf elementarem Niveau in mündlicher und schriftlicher Form zu diskutieren. | **Arbeitsaufwand:**
 Präsenzzeit:
 56 Stunden
 Selbststudium:
 214 Stunden |

Lehrveranstaltungen: **1. Einführungskurs in die Praktische Philosophie** (Vorlesung, Seminar) *Angebotshäufigkeit:* jedes Semester; Einführungskurs bevorzugt im Wintersemester	2 SWS
2. Proseminar zur Praktischen Philosophie	2 SWS
Es muss <u>eine</u> der nachfolgenden Prüfungsformen (Klausur, Hausarbeit oder Essays) absolviert werden.	

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfung: Hausarbeit (max. 15 Seiten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfung: Essay (max. 15 Seiten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfungsanforderungen: Verständnis zentraler Begriffe, Probleme und Theorieansätze der praktischen Philosophie. Darstellung und Diskussion von Themen der praktischen Philosophie auf elementarem Niveau in schriftlicher Form. Die Prüfung wird in einem Proseminar (nicht in der Einführungsvorlesung oder im Einführungsseminar!) abgelegt.	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**

keine	keine
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Prof. Dr. Holmer Steinfath
Angebotshäufigkeit:	**Dauer:**
jedes Semester, Einführungskurs bevorzugt im Wintersemester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	1 - 3
Maximale Studierendenzahl:	
100	

Georg-August-Universität Göttingen **Modul B.Phi.03: Basismodul Geschichte der Philosophie** *English title: Basic Studies in History of Philosophy*	9 C 4 SWS

Lernziele/Kompetenzen: 1. In einem Einführungskurs (Vorlesung oder Einführungsseminar) erwerben die Studierenden einen Überblick über Epochen der Philosophiegeschichte, erste Bekanntschaft mit jeweils zentralen Themenbereichen und einzelnen Werken klassischer Autoren. 2. In einem Proseminar (Basisseminar) erlangen die Studierenden Verständnis klassischer Texte der Philosophie sowie Grundfertigkeiten der Analyse eines Textes unter historischen und systematischen Gesichtspunkten.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden

Lehrveranstaltungen: **1. Einführungskurs in die Geschichte der Philosophie** (Vorlesung, Seminar) **2. Proseminar zur Geschichte der Philosophie** **Es muss <u>eine</u> der nachfolgenden Prüfungsformen (Klausur, Hausarbeit oder Essays) absolviert werden.**	 2 SWS 2 SWS

Prüfung: Klausur (120 Minuten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfung: Essay (max. 15 Seiten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfung: Hausarbeit (max. 15 Seiten) **Prüfungsvorleistungen:** regelmäßige Teilnahme an einem Proseminar; kleinere schriftliche Leistungen (max. 2 S.; Protokoll, Kurzreferat o.ä.) in beiden Lehrveranstaltungen	9 C

Prüfungsanforderungen: Überblick über Epochen der Philosophiegeschichte, elementares Verständnis zentraler Themen und klassischer philosophischer Texte. Darstellung und Diskussion philosophiegeschichtlicher Themen auf elementarem Niveau in schriftlicher Form. Die Prüfung wird in einem Proseminar (nicht in der Einführungsvorlesung oder im Einführungsseminar!) abgelegt.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache:	**Modulverantwortliche[r]:**

Deutsch	Prof. Dr. Bernd Ludwig
Angebotshäufigkeit: jedes Semester; Einführungskurs bevorzugt im SoSe	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 2 - 3
Maximale Studierendenzahl: 100	

Georg-August-Universität Göttingen	8 C
Module B.Phy.1551: Introduction to Astrophysics	6 WLH

Learning outcome, core skills:	Workload:
After successful completion of the modul students should be familiar with the basic concepts of astrophysics in observation and theory.	Attendance time: 84 h Self-study time: 156 h

Course: Lecture and exercises for introduction to astrophysics	
Examination: oral (approx. 30 minutes) or written (120 min.) exam **Examination prerequisites:** At least 50% of the homework of the excercises have to be solved successfully. **Examination requirements:** Observational techniques, Planets and exoplanets, planet formation, stellar formation, structure and evolution, galaxies, AGN and quasars, cosmology, structure formation	8 C

Admission requirements:	Recommended previous knowledge:
none	none
Language: English, German	**Person responsible for module:** Prof. Dr. Jens Niemeyer
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: three times	**Recommended semester:** Bachelor: 5 - 6; Master: 1
Maximum number of students: 120	

Georg-August-Universität Göttingen **Modul B.WIWI-BWL.0014: Rechnungslegung der Unternehmung** *English title: Financial Accounting*	6 C 4 SWS

Lernziele/Kompetenzen: Gegenstand der Veranstaltung ist die Vermittlung der Grundlagen externer Rechnungslegung nach Maßgabe handelsrechtlicher und internationaler Vorschriften (International Financial Reporting Standards (IFRS)). Studierende sollen nach erfolgreichem Besuch der Veranstaltung Kenntnis der Grundzüge handelsrechtlicher und internationaler Rechnungslegung haben, markante Unterschiede und grundlegende Entwicklungslinien kennen und in der Lage sein, die entsprechenden Rechenwerke zu lesen und für analytische, entscheidungsunterstützende Zwecke zu verwenden.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltungen:	
1. Rechnungslegung der Unternehmung (Vorlesung)	2 SWS
2. Rechnungslegung der Unternehmung (Übung)	2 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: Nachweis der Kenntnis der Grundlagen der Rechnungslegung nach handelsrechtlichen Grundsätzen und nach International Financial Reporting Standards im Spannungsfeld nationaler Institutionen und internationaler Konvergenzbestrebungen	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Modul "Jahresabschluss"
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Jörg-Markus Hitz
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 3 - 4
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-BWL.0023: Grundlagen der Versicherungstechnik** *English title: Actuarial Techniques*	6 C 2 SWS
Lernziele/Kompetenzen: 1. Begriffsbestimmungen, Struktur und Elemente des Risikotransfers; 2. Elemente der Risikopolitik (u.a. Grundlagen der Prämienkalkulation und -differenzierung, Risikoauslese und Underwriting, Reservierungspolitik, Schadenmanagement, Rück- und Mitversicherung,); 3. Geschäftsmodelle der Versicherungssparten (Lebensversicherung, Krankenversicherung, Schadenversicherung, Rückversicherung); 4. Risikomanagement und Solvabilitätsvorschriften, insbesondere Solvency II; 5. Finanzierung und Kapitalanlage Die Studierenden sollen die folgenden Fähigkeiten und Kenntnisse erwerben: 1. Kenntnis und Verständnis der Funktionsweise der Versicherungsmärkte; 2. Kenntnis und Verständnis der Geschäftsmodelle und der technischen Grundlagen in der Lebens-, Kranken-, Schadens- und Rückversicherung sowie in der Betrieblichen Altersversorgung; 3. Kenntnis und Verständnis des Risikomanagements und der Solvabilitätsvorschriften incl. Methoden der Risikobewertung; 4. Kenntnis und Verständnis der Finanzierungsvorgänge incl. Rückstellungsbildung in der Versicherungswirtschaft, 5. Bewertung der zentralen Unterschiede in den Geschäftsmodellen der privaten Versicherungswirtschaft, der gesetzlichen Versicherungssysteme und der Kreditwirtschaft, 6. Kenntnis des Instrumentariums der Risikopolitik eines Versicherungsunternehmens, auch anhand konkreter praktischer Beispiele; 7. Fähigkeit, einfache Berechnungen zur Versicherungstechnik vorzunehmen.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden

Lehrveranstaltung: Grundlagen der Versicherungstechnik (Vorlesung)	2 SWS

Prüfung: Klausur (120 Minuten)	6 C

Prüfungsanforderungen: 1. Nachweis von Kenntnissen der Funktion eines Versicherungsmarktes und seiner wesentlichen Determinanten und Begriffe; 2. Nachweis von Kenntnissen im Risikomanagement, der Solvabilitätsanforderungen und Risikobewertung; 3. Nachweis von Kenntnissen der Risikopolitik und der Geschäftsmodelle der Versicherungssparten;	

4. Nachweis von Kenntnissen der Finanzierung des Risikotransfers;

5. Bewertung der Rolle der Versicherungswirtschaft zum Markt der Kreditwirtschaft und der gesetzlichen Versicherungssysteme;

6. Einfache Berechnungen zur Versicherungstechnik

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
keine	keine
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Prof. Dr. Martin Balleer
Angebotshäufigkeit:	**Dauer:**
in der Regel jedes zweite Semester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-BWL.0038: Supply Chain Management** *English title: Supply Chain Management*	6 C 2 SWS

Lernziele/Kompetenzen: Die Studierenden sollen in der Lage sein, Instrumente, mit denen Distributionsaufgaben von Industrie- und Handelsunternehmen gelöst und koordiniert werden, anzuwenden, zu beurteilen und bei Bedarf anzupassen. Hierzu zählen insbesondere die gemeinsame Prognose der Nachfrage sowie die koordinierte Bestell- und Bestandspolitik von Handel und Industrie.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden

Lehrveranstaltung: Supply Chain Management (Vorlesung)
Inhalte:
1. Begriffliche Grundlagen des Supply Chain Managements
 	
2. Analyserahmen für die Ausgestaltung der Supply Chain
 	
  • Der Management-Zyklus
  • Elemente und Strukturen des entscheidungsorientierten Ansatzes
  • Entscheidungsfelder des Supply Chain Managements
  • Zielgrößen des Supply Chain Managements
  • Analyse der Einflussfaktoren
 	
3. Koordination der Supply Chain
 	
  • Begriffliche Grundlagen
  • Transaktionale versus relationale Koordination
  • Supplier Relationship Management
  • Beziehungsstile im Business to Business Geschäft
 	
4. Standortplanung
 	
  • Ziele, Einflussfaktoren und Optionen der Lagerstruktur
  • Methoden zur Lösung von Standortproblemen
 	
5. Prognose der Nachfrage
 	
  • Elemente eines Prognosesystems
  • Regressionsanalyse im Rahmen der Kausalanalyse
  • Grundlagen der Zeitreihenanalyse
  • Exponentielle Glättung Saisonmodell
 	
6. Bestellmengenplanung
 	
  • Bestellentscheidungen bei deterministischer Nachfrage
  • Bestellentscheidungen bei stochastischer Nachfrage
  • Das Joint Economic Lot Size (JELS) Modell
 	
7. Technologische Voraussetzungen
 	
  • Elektronischer Datenaustausch
  • Standardisierung
  • RFID
	2 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen:	
Nachweis von Fähigkeiten, Probleme der wirtschaftsstufenübergreifenden Koordination von Beschaffungs- und Distributionsproblemen zu analysieren. Beherrschung von Instrumenten, mit denen insbesondere die Schnittstelle zwischen Industrie und Handel abgestimmt wird. Kritische Diskussion der Ergebnisse solcher Instrumente.	

Zugangsvoraussetzungen:	Empfohlene Vorkenntnisse:
keine	Modul B.WIWI-BWL.0005: Marketing
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Prof. Dr. Waldemar Toporowski
Angebotshäufigkeit:	**Dauer:**
jedes Sommersemester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	4 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:
Je nach Kapazität findet eine zusätzliche Übung mit Fallstudien statt. Informationen dazu stehen zu Beginn des Semesters im UniVz.

Georg-August-Universität Göttingen **Module B.WIWI-BWL.0087: International Marketing**	6 C 2 WLH

Learning outcome, core skills: After successful attendance the students should understand the foundations of international marketing as well as the diverse environments of global markets. Moreover, they should be able to assess global marketing opportunities and develop international marketing strategies.	**Workload:** Attendance time: 28 h Self-study time: 152 h

Course: International Marketing (Lecture) *Contents*: - Introduction to international marketing - Social and cultural environments - Political, legal, and regulatory environments - Assessing global marketing opportunities - International marketing strategy (country selection, entry-modes, international marketing mix) - Branding across cultures The course conveys theoretical knowledge which is enriched by case studies. Specific contents are international trade developments, culture and values (incl. approaches by Hofstede, Inglehart, & Schwartz), political risk assessment, legal environments, international marketing research, competitive analysis and strategy (incl. Porter's Five Forces), emerging markets, entry strategy (incl. Uppsala model vs. born global approach), country selection, market entry modes, international marketing mix, and the country-of-origin effect.	2 WLH

Examination: Written examination (90 minutes)	6 C

Examination requirements: Foundations of international marketing, social, cultural, political and legal environments of global markets, assessing global marketing opportunities, developing international marketing strategies, branding across cultures	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Steffen Jahn
Course frequency: each winter semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 6
Maximum number of students: not limited	

Georg-August-Universität Göttingen **Module B.WIWI-BWL.0088: International Business**	6 C 4 WLH

Learning outcome, core skills: Through learning about the opportunities and problems that are presented in a global business environment, students will be better able to understand the dynamics of global business. Key objectives include: Understanding the political, economic and cultural differences in international business; Recognizing issues, problems and procedures of international business operations in the global marketplace; Understanding how companies deal with these issues; and Applying international business concepts to real life examples (case studies).	**Workload:** Attendance time: 56 h Self-study time: 124 h

Courses: **1. International Business (Lecture)** *Contents*: This course is designed to provide a broad understanding of the scope and expansion of the business operations of multinational corporations (MNCs) in a rapidly changing global economy. Main topics include: The international business (IB) environment; Corporate policy and Strategy ; and Management of international operations.	2 WLH
2. Case Study Discussion (Tutorial) *Contents*: The course will be based on case studies, readings, some presentations, and, above all, the debate and the exchange of ideas and experiences. Throughout the course, students will be encouraged to bring their insights and thoughts on the material assigned into class discussion.	2 WLH

Examination: Written examination (90 minutes) **Examination requirements:** The final exam is divided into two parts: multiple-choice (40%) and essay portion (60%). The multiple-choice questions will be based on the contents of the lectures and assigned reading materials. In the essay portion, there will be three questions from which you will choose two to answer. In the essays, you are expected to show that you have understood a certain IB concept and demonstrate how it can be applied to a real life example.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Prof. Jaime Bonache
Course frequency: every second semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 3 - 6
Maximum number of students:	

not limited	

Georg-August-Universität Göttingen **Modul B.WIWI-OPH.0009: Recht**	8 C 6 SWS

| **Lernziele/Kompetenzen:**
Nach erfolgreichem Absolvieren des Moduls:

- haben die Studierenden grundlegende Kenntnisse des Zivilrechts und des Handelsrechts erlangt;

- haben die Studierenden gelernt, zwischen Verpflichtungsgeschäft und Verfügungsgeschäft sowie zwischen vertraglichen und deliktischen Ansprüchen zu differenzieren;

- kennen die Studierenden die wesentlichen Vertragstypen;

- kennen die Studierenden die dogmatischen Konzeptionen des Zivilrechts in ihrer systematischen, ideellen und praktischen Bedeutung;

- kennen die Studierenden die Methoden der Gesetzesauslegung (Wortlaut, systematische, historische, teleologische Auslegung) und können diese anwenden;

- können die Studierenden die Technik der Falllösung im Bereich des Zivilrechts anwenden;

- sind die Studierenden in der Lage, die erworbenen Kenntnisse bei der Lösung einschlägiger Fälle umzusetzen und sich mit den aufgeworfenen Rechtsfragen kritisch auseinanderzusetzen. | **Arbeitsaufwand:**
Präsenzzeit:
84 Stunden
Selbststudium:
156 Stunden |

Lehrveranstaltungen:	
1. Recht (Vorlesung)	4 SWS
2. Recht (Übung)	2 SWS

| **Prüfung: Klausur (120 Minuten)**
Prüfungsanforderungen:
Durch die Modulprüfung weisen die Studierenden nach, dass sie,

- grundlegende Kenntnisse im Zivil- und Handelsrecht aufweisen,

- ausgewählte Tatbestände des Zivilrechts beherrschen,

- die zugehörigen methodischen Grundlagen beherrschen und

- systematisch an einen zivilrechtlichen Fall herangehen und diesen in vertretbarer Weise lösen können. | 8 C |

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Dr. Roman Heidinger
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 2

Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-VWL.0001: Mikroökonomik II** *English title: Microeconomics II*	6 C 4 SWS

Lernziele/Kompetenzen: Nach erfolgreicher Absolvierung der Veranstaltung sind Studierende in der Lage:	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Nach erfolgreicher Absolvierung der Veranstaltung sind Studierende in der Lage:

- verschiedene Marktformen voneinander zu unterscheiden und deren Wohlfahrtseffekte zu analysieren.
- zwischen der Gleichgewichtsanalyse eines einzelnen Marktes und der Analyse des allgemeinen Gleichgewichts aller Märkte zu unterscheiden und selbstständig anzuwenden.
- das Prinzip intertemporaler Entscheidungen der Haushalte zu verstehen und in die optimale Entscheidung der Haushalte einzubeziehen.
- die grundlegenden Zusammenhänge von Risiko und Versicherungsmärkten zu verstehen und in die optimale Entscheidung der Haushalte einzubeziehen.
- die Grundlagen simultaner und sequentieller Spieltheorie zu verstehen und selbstständig anzuwenden.
- die Konsequenzen asymmetrischer Informationen für das Verhalten der Marktteilnehmer zu analysieren.

Lehrveranstaltungen: **1. Mikroökonomik II** (Vorlesung) *Inhalte*: **Wettbewerbsmärkte**	2 SWS

1. Wettbewerb und Monopol auf einem einzigen Markt

Unterscheidung zwischen vollständiger Konkurrenz, Monopol und Oligopol und grafische Analyse des Marktgleichgewichts und der allgemeinen Wohlfahrt je nach Marktform.

2. Allgemeines Gleichgewicht

Grafische Analyse des allgemeinen Marktgleichgewichts mithilfe der Edgeworth-Box. Definition des Gesetzes von Walras sowie des ersten und zweiten Satzes der Wohlfahrtsökonomik.

3. Ersparnis und Investition

Mathematische und grafische Abhandlung der intertemporalen Budgetgleichung der Haushalte bei vollkommenem und unvollkommenem Kapitalmarkt. Mathematische und grafische Betrachtung von Investitionen als intertemporale Produktionsentscheidung von Unternehmen.

4. Risiko und Versicherung

Mathematische und grafische Analyse der Entscheidung von Haushalten unter Unsicherheit. Einführung der Erwartungsnutzenhypothese und der von-Neumann-Morgenstern-Nutzenfunktion.

Spieltheorie und oligopolistische Märkte

5.   Spiele in Normalform

Grundlagen simultaner Spiele am Beispiel des Gefangenendilemmas und Bestimmung von dominanter Strategie und Nash-Gleichgewicht.

6.   Sequenzielle Entscheidungen

Analyse sequentieller Spiele mithilfe des Entscheidungsbaumes.

7.   Oligopoltheorie

Mathematische und grafische Analyse von Cournot-,Stackelberg- und Bertrand-Gleichgewicht.

8.   Asymmetrische Information

Analyse des Verhaltens von Marktteilnehmern im Fall von asymmetrisch verteilter Information am Beispiel von moral harzard adverse selection.

2. Mikroökonomik II (Übung) *Inhalte*: In den Übungen werden die Inhalte der Vorlesung anhand von Aufgaben wiederholt und vertieft.	2 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: • Aufgaben sind sowohl rechnerisch als auch grafisch und verbal intuitiv zu lösen. • Nachweis grundlegender Kenntnisse des Wettbewerbsgleichgewichts eines Marktes und des allgemeinen Gleichgewichts, insbesondere der Rolle des Preises für die Markträumung. • Nachweis der Fähigkeit zur grafischen und mathematischen Analyse verschiedener Marktformen und deren Wohlfahrtseffekte. • Nachweis grundlegender Kenntnisse der Spieltheorie und Oligopoltheorie und der Fähigkeit der Bestimmung der optimalen Strategie der Marktteilnehmer. • Nachweis der Fähigkeit zur Bewertung der Risikoeinstellung von Marktteilnehmern und der Konsequenzen für die optimale Entscheidung.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Modul B.WIWI-OHP.0007: Mikroökonomik I
Sprache:	**Modulverantwortliche[r]:**

Deutsch	Prof. Dr. Robert Schwager
	Prof. Dr. Tino Berger Prof. Dr. Claudia Keser, Jun.-
	Prof. Dr. Sebastian Vollmer
Angebotshäufigkeit:	**Dauer:**
jedes Semester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	2 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen	6 C
Modul B.WIWI-VWL.0002: Makroökonomik II *English title: Macroeconomics II*	4 SWS

Lernziele/Kompetenzen:	Arbeitsaufwand:
Die Studierenden • verstehen die Zusammenhänge auf Arbeitsmärkten, kennen die Determinanten von Arbeitsangebot und Arbeitsnachfrage und können ein Arbeitsmarktgleichgewicht darstellen. • sind in der Lage, bekannte gesamtwirtschaftliche Modelle durch die arbeitsmarkttheoretischen Erkenntnisse zu erweitern und dadurch lang- und kurzfristige Wirkungen wirtschaftspolitischer Maßnahmen zu unterscheiden. • können die Zusammenhänge zwischen Inflation und Arbeitslosigkeit anhand der Phillips-Kurve darstellen und diese kritisch reflektieren. • sind mit verschiedenen Wachstumsmodellen vertraut und kennen die Bedeutung von Wachstum für eine Volkswirtschaft. • sind in der Lage, ein gesamtwirtschaftliches Modell durch die Beziehungen zum Ausland zu erweitern und anhand dieses Modells die Wirkung verschiedener wirtschaftspolitischer Maßnahmen zu diskutieren. • kennen die Eigenschaften verschiedener Währungssysteme und können deren Vor- und Nachteile unter Einbeziehung ihres Einflusses auf die Wirkung wirtschaftspolitischer Maßnahmen beurteilen.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltungen:	
1. Makroökonomik II (Vorlesung) *Inhalte*: Die Vorlesung vertieft den Stoff des Moduls Makroökonomische Theorie I durch die Berücksichtigung verschiedener Erweiterungen. Einen Schwerpunkt bildet dabei die Diskussion arbeitsmarkttheoretischer Zusammenhänge, die in bekannte gesamtwirtschaftliche Modelle einbezogen werden, um kurz- und langfristige Wirkungen wirtschaftlicher Maßnahmen unterscheiden zu können. Weitere Schwerpunkte sind die Analyse von Wirtschaftswachstum sowie mikroökonomischer Fundierungen makroökonomischer Annahmen. Schließlich werden wirtschaftspolitische Maßnahmen in offenen Volkswirtschaften im klassischen und keynesianischen Kontext analysiert und deren Wirkung in verschiedenen Währungssystemen diskutiert. Aus diesen Überlegungen werden Aussagen über die Geeignetheit verschiedener Währungssysteme abgeleitet, wobei auch auf die Europäische Währungsunion eingegangen wird.	2 SWS
2. Makroökonomik II (Übung) *Inhalte*: Im Rahmen der begleitenden Übung/Tutorium vertiefen die Studierenden die Kenntnisse aus der Vorlesung anhand ausgewählter theoretischer Fragestellungen.	2 SWS
Prüfung: Klausur (90 Minuten)	6 C
Prüfungsanforderungen:	

Nachweis von Kenntnissen über arbeitsmarkttheoretische Zusammenhänge und den Modifikationen gesamtwirtschaftlicher Modelle durch deren Berücksichtigung. Nachweis der Kenntnis und souveränen Handhabung neoklassischer und keynesianischer Gütermarkt-Hypothesen. Die Studierenden sind in der Lage, die Zusammenhänge zwischen Inflation und Arbeitslosigkeit zu begründen, theoretisch darzustellen und zu diskutieren. Außerdem kennen sie Wachstumsmodelle und deren Bedeutung für die Volkswirtschaften. Nachweis von Kenntnissen über die Wirkungsweise verschiedener Währungssysteme und einer Währungsunion. Nachweis der Kenntnis und souveränen Anwendung des Mundell-Fleming-Modells zur Analyse der Wirkungen verschiedener wirtschaftspolitischer Maßnahmen für eine offene Volkswirtschaft bei unterschiedlichen Wechselkurssystemen.

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
keine	Modul B.WIWI-OPH.0008: Makroökonomik I
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Prof. Dr. Gerhard Rübel
	Prof. Dr. Krisztina Kis-Katos, Dr. Katharina Werner
Angebotshäufigkeit:	**Dauer:**
jedes Semester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	2 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-VWL.0005: Grundlagen der internationalen Wirtschaftsbeziehungen** *English title: International Economics Foundations*	6 C 4 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Die Vorlesung besteht aus drei Teilen. In Teil 1 werden die Erfassung außenwirtschaftlicher Beziehungen einer Volkswirtschaft und die Gründe der Entstehung von dabei auftretenden Ungleichgewichten analysiert. Dabei wird auch die gesellschaftliche Bedeutung solcher Ungleichgewichte und Möglichkeiten ihres Abbaus diskutiert. Teil 2 gibt einen Überblick über die Ursachen und die Folgen der internationalen Arbeitsteilung. Dabei werden verschiedene Theorien analysiert und deren volkswirtschaftlichen Konsequenzen dargestellt. Auch die Gründe, die Möglichkeiten und die Folgen staatlicher Eingriffe in die Weltmarktpreisbildung werden analysiert. In Teil 3 werden die verschiedenen Erscheinungsformen von Devisenmärkten und die dort praktizierten Geschäfte untersucht und die Bestimmungsfaktoren von Wechselkursen diskutiert und theoretisch vertieft.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Die Studierenden

1.   Sind mit der Erfassung außenwirtschaftlicher Beziehungen einer Volkswirtschaft vertraut, kennen möglich Ursachen für die Entstehung von Ungleichgewichten und können deren Bedeutung für nationale Volkswirtschaften und für die Welt als Ganzes kritisch reflektieren.

2.   Kennen verschiedene Ursachen für die Teilnahme eines Landes an der internationalen Arbeitsteilung

3.   Können verschiedene Ursachen für den relativen Preisvorteil eine Landes theoretisch fundieren und deren wirtschaftspolitische Konsequenzen darstellen

4.   Sind mit den Wohlfahrtswirkungen von Außenhandel vertraut und können deren gesellschaftlichen Folgen reflektieren

5.   Kennen mögliche staatliche Instrumente zur Beeinflussung von Im- und Exporten und können die sich daraus ergebenden gesellschaftlichen Konsequenzen einzelstaatlich und weltwirtschaftlich bewerten

6.   Sind mit den Voraussetzungen und den Motiven einer multinationalen Unternehmertätigkeit vertraut

7.   Haben einen Überblick über die verschiedenen Erscheinungsformen von Devisenmärkten und den Motiven der dort handelnden Akteure und können die dabei bestehenden Zusammenhänge darstellen

8.   Sind vertraut mit verschiedenen Determinanten von Wechselkursen und können deren Relevanz kritisch reflektieren

Im Rahmen der begleitenden Übung vertiefen die Studierenden die Kenntnisse aus der Vorlesung anhand ausgewählter theoretischer Fragestellungen.

Lehrveranstaltungen:	
1. Grundlagen der internationalen Wirtschaftsbeziehungen (Vorlesung)	2 SWS
2. Grundlagen der internationalen Wirtschaftsbeziehungen (Übung)	2 SWS
Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen:

Nachweis von Kenntnissen über die Erfassung außenwirtschaftlicher Beziehungen einer Volkswirtschaft, den Ursachen dabei entstehender Ungleichgewichte und deren wirtschaftspolitischen Folgen. Kenntnisse über die Gründe der internationalen Arbeitsteilung, den Theorien zur Bestimmung relativer Preisvorteile eines Landes und den Folgen der internationalen Arbeitsteilung. Grundlegende Kenntnisse staatlicher Einflüsse auf die Weltmärkte und der Ursachen und Wirkung einer international orientierten Unternehmertätigkeit. Kenntnisse über die Erscheinungsformen von Devisenmärkten und die dort praktizierten Geschäfte sowie der Bestimmungsfaktoren von Wechselkursen.

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Modul "Makroökonomik I", Modul "Mikroökonomik I"
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Gerhard Rübel
Angebotshäufigkeit: jedes Wintersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 3 - 6
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-VWL.0006: Wachstum und Entwicklung** *English title: Economic Growth and Development*	6 C 4 SWS

Lernziele/Kompetenzen: Die Studierenden sollen in diesem Modul ein grundlegendes Verständnis für die Ursachen und Konsequenzen von langfristigem Wirtschaftswachstum bekommen. Sie sollen sich mit den Standardmodellen der Wachstumstheorie vertraut machen, empirische Tests dieser bewerten und wirtschaftspolitische Implikationen ziehen und kritisch reflektieren.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltungen:
1. Wachstum und Entwicklung (Vorlesung)
Inhalte:
1) Faktorakkumulation
 	
  i) Kapitalakkumulation
 	
  ii) Das Modell überlappender Generationen.
 	
  iii) Bevölkerungswachstum und Wirtschaftswachstum
 	
  iv) Der Demographische Übergang
 	
  v) Humankapital: Gesundheit und Ausbildung
 	
  vi) Warum fließt Kapital nicht von reichen zu armen Ländern?
 	
2) Produktivität
 	
  i) Wachstumszerlegung
 	
  ii) Erfindungen und Ideen
 	
  iii) Technologischer Fortschritt und Wachstum vor dem 18. Jahrhundert
 	
  iv) Technologischer Fortschritt und Wachstum heute
 	
3) Deep Determinants
	2 SWS

2. Wachstum und Entwicklung (Übung) *Inhalte*: In der begleitenden Übung sollen die Studierenden anhand von Übungsaufgaben ihr Wissen zu den in der Vorlesung behandelten Themen vertiefen und erweitern.	2 SWS
Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: Nachweis: • fundierter Kenntnisse über die Ursachen und Konsequenzen langfristiger Einkommensunterschiede • von grundlegendem Verständnis der behandelten Wachstumsmodelle • von der Fähigkeit zum selbständiges Lösen von Anwendungsbeispielen im Themenbereich der Vorlesung (theoretisch, graphisch und verbal)	

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
keine	Modul B.WIWI-OPH.0008: Makroökonomik I, Modul B.WIWI-OPH.0006: Statistik
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Prof. Dr. Holger Strulik
	Dr. Katharina Werner
Angebotshäufigkeit:	**Dauer:**
jedes zweite Semester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	3 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-VWL.0007: Einführung in die Ökonometrie** *English title: Introduction to Econometrics*	6 C 6 SWS

Lernziele/Kompetenzen: Das Modul gibt eine umfassende Einführung in die ökonometrische Analyse ökonomischer Fragestellungen. Die Studierenden erlernen mit Hilfe der Methoden linearer Regressionsanalyse erste eigene empirische Studien durchzuführen. Die vermittelten Kompetenzen beinhalten die Spezifikation von ökonometrischen Modellen, die Modellselektion und –schätzung. Darüber hinaus werden Studierende mit ersten Problemen im Bereich der linearen Regression wie beispielsweise Heteroskedastizität und Autokorrelation vertraut gemacht. Dieses Modul bildet das Fundament für weiterführende Ökonometrie Veranstaltungen.	**Arbeitsaufwand:** Präsenzzeit: 84 Stunden Selbststudium: 96 Stunden

Lehrveranstaltungen:
1. Einführung in die Ökonometrie (Vorlesung)
Inhalte:
 	
  1. Einführung in lineare multiple Regressionsmodelle, Modellspezifikation, KQ-Schätzung, Prognose und Modellselektion, Multikollinearität und partielle Regression.
  2. Lineares Regressionsmodell mit normalverteilten Störtermen, Maximum-Likelihood-Schätzung, Intervallschätzung, Hypothesentests
  3. Asymptotische Eigenschaften des KQ- und GLS Schätzers
  4. Lineares Regressionsmodell mit verallgemeinerter Kovarianzmatrix, Modelle mit autokorrelierten und heteroskedastischen Fehlertermen, Testen auf Autokorrelation und Heteroskedastizität.
	2 SWS

2. Einführung in die Ökonometrie (Übung) *Inhalte*: Die Großübung vertieft die Inhalte der Vorlesung anhand von Rechenaufgaben mit ökonomischen Fragestellungen und Datensätzen. Weiterhin werden theoretische Konzepte aus der Vorlesung detailliert hergeleitet.	2 SWS
3. Einführung in die Ökonometrie (Tutorium) *Inhalte*: Das Tutorium vertieft die Inhalte der Vorlesung und Großübung anhand von Rechenaufgaben. Ein großer Teil beinhaltet das Schätzen von ökonometrischen Modellen mit realen Daten und mit Hilfe des Softwareprogramms Eviews.	2 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: Lineares Regressionsmodell, Modellspezifikation, Annahmen, KQ-Schätzung, Interpretation von Modellparametern, Gauss-Markov Theorem, Prognose, Prognosefehlervarianz, Bestimmtheitsmaß, Modellvergleich, Frisch-Waugh Theorem, Mitttelwertbereinigtes Modell, Modellunsicherheit, Multikollinearität, Maximum-Likelihood Schätzung, Schätzeffizienz, Intervallschätzung, Hypothesentests, asymptotische	

Eigenschaften des KQ- und GLS Schätzers, Heteroskedastizität, Autokorrelation, Testen von Heteroskedastizität und Autokorrelation.

Zugangsvoraussetzungen:	Empfohlene Vorkenntnisse:
keine	B.WIWI-OPH.0002: Mathematik, B.WIWI-OPH.0006: Statistik
Sprache:	Modulverantwortliche[r]:
Deutsch	Prof. Dr. Helmut Herwartz
Angebotshäufigkeit:	Dauer:
jedes Semester	1 Semester
Wiederholbarkeit:	Empfohlenes Fachsemester:
zweimalig	3
Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-VWL.0008: Geldtheorie und Geldpolitik** *English title: Money and International Finance*	6 C 4 SWS

Lernziele/Kompetenzen: Die Vorlesung bietet insbesondere einen Überblick über die grundsätzliche Bedeutung von Geld sowie seines Innen- und Außenwertes. Es werden die theoretischen Möglichkeiten der Geldschaffung und der Bestimmungsfaktoren der Geldnachfrage dargestellt und ihre praktische Bedeutung diskutiert. Nach der Darstellung eines Geldmarktgleichgewichts werden die Ziele, die Strategien und die Instrumente der Geldpolitik analysiert und außenwirtschaftliche Einflüsse untersucht. Schließlich werden Theorien zur Wirkung der Geldpolitik dargestellt und diese kritisch reflektiert.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Die Studierenden

1.   Sind mit den grundlegenden Merkmalen und Funktionen von Geld vertraut und können die gesellschaftliche Relevanz von Geld einordnen

2.   Kennen die volkswirtschaftliche Bedeutung des Zinses und können diese kritisch reflektieren

3.   Wissen, wie Inflation gemessen wird und können die Wirkung und die gesellschaftliche Bedeutung von Inflation erfassen

4.   Können Determinanten der Geldnachfrage darstellen und die Möglichkeiten und Grenzen der Schaffung von Geld identifizieren und sind mit den Bedingungen eines Geldmarktgleichgewichts vertraut

5.   Haben einen Überblick über die Ziele, die Strategien und die Instrumente der Geldpolitik und die außenwirtschaftliche Einflüsse auf deren Wirksamkeit

6.   Kennen die Theorien zur Wirkung geldpolitischer Maßnahmen und können diese kritisch reflektieren

Im Rahmen der begleitenden Übung vertiefen die Studierenden die Kenntnisse aus der Vorlesung anhand ausgewählter theoretischer Fragestellungen.

Lehrveranstaltungen: **1. Geldtheorie und Geldpolitik** (Vorlesung)	2 SWS
2. Geldtheorie und Geldpolitik (Übung)	2 SWS
Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: Nachweis von Kenntnissen der Geldtheorie und der Geldpolitik, insbesondere der Analyse der Bedeutung und der Funktionen von Geld sowie seines Innen- und Außenwerts. Nachweis von Kenntnissen über die Determinanten von Geldangebot und Geldnachfrage sowie den Zusammenhängen eines Geldmarktgleichgewichts. Außerdem sollen die Ziele, die Strategien und die Instrumente der Geldpolitik erklärt,	

ihre theoretischen Wirkungskanäle dargestellt und ihre praktische Umsetzbarkeit und ihr Erfolg kritisch reflektiert werden können.

Zugangsvoraussetzungen:	Empfohlene Vorkenntnisse:
keine	Modul "Makroökonomik I"
Sprache:	**Modulverantwortliche[r]:**
Deutsch	Prof. Dr. Gerhard Rübel
Angebotshäufigkeit:	**Dauer:**
jedes Sommersemester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	3 - 6
Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-VWL.0010: Einführung in die Institutionenökonomik** *English title: Foundations of Institutional Economics*	6 C 2 SWS

Lernziele/Kompetenzen: Die Studierenden:	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden

Die Studierenden:

- kennen verschiedene Definitionen von internen und externen Institutionen, sowie deren Relevanz in der wirtschaftspolitischen Normsetzung.
- kennen die Rolle von Eigentumsrechten und deren Durchsetzung in der ökonomischen Theorie und Praxis.
- kennen Konzepte von Transaktionskosten und deren Wirkung auf die
- Interaktion von Individuen und Firmen auf dem Markt.
- kennen die Rolle des Staates bei der Einführung und Durchsetzung externer Institutionen.
- kennen Grundlagen der Neuen Politischen Ökonomik und deren Theorie der Demokratie, Bürokratie und Interessengruppe.
- kennen institutionenökonomische Analysekonzepte wie die Prinzipal-Agenten-Theorie oder Moral Hazard, sowie experimentelle Forschungsergebnisse zur Institutionenanalyse.
- kennen die Rolle und den Wandel von Verhaltensmodellen als wirtschaftspolitisches Instrument.

Lehrveranstaltung: Einführung in die Institutionenökonomik (Vorlesung) *Inhalte*:	2 SWS

Diese Vorlesung soll die theoretischen Grundlagen der Institutionenökonomik vermitteln und verschiede (Anwendungs-)Bereiche aufzeigen.

Die Vorlesung ist inhaltlich in drei Blöcke unterteilt. Im ersten wird die institutionenökonomische Theorie vermittelt. Dabei wird mit der Abgrenzung zwischen internen und externen Institutionen, sowie ihrer Entwicklung und Bedeutung für das gesellschaftliche Zusammenleben begonnen. Dabei wird auch auf ihre Relevanz in der wirtschaftspolitischen Normsetzung und die Durchsetzungsmechanismen eingegangen. Im Anschluss werden Verfügungsrechte als eine der zentralen externen Institutionen bezüglich Konzept und Umsetzungsform erläutert und analysiert. Die Governancestrukturen sollen mithilfe der drei Akteure Unternehmen, Markt sowie Staat und politischer Prozess vermittelt werden. Dabei werden Theorie und Anwendungsmöglichkeiten von Transaktionskosten und deren Wirkung auf die Interaktion von Individuen und Firmen erörtert. Die Prinzipal-Agenten-Theorie und Moral Hazard dienten dabei als institutionenökonomische Analysekonzepte. Zudem sind die Rolle des Staates bei der Einführung und Durchsetzung externer Institutionen, sowie die Grundlagen der Neuen Politischen Ökonomik und deren Theorien der Demokratie, Bürokratie und Interessengruppen Gegenstand der Vorlesung.

Der zweite Block konzentriert sich auf kulturvergleichende Institutionenökonomik. Der Fokus liegt auf dem Varieties of Capitalism-Ansatz von Hall & Soskice. Zudem wird

der Zusammenhang von Institutionen mit wirtschaftlichem Wachstum und Entwicklung vermittelt.

Der dritte Block thematisiert behavioral Governance und damit die Anwendungsmöglichkeiten von Institutionenökonomik. Beginnend mit der Rolle und dem Wandeln von ökonomischen Verhaltensmodellen und ihrer Relevanz für die Institutionenökonomik wird unter anderem das Verhaltensmodell des homo oeconomicus institutionalis vermittelt. Daran anschließend wird das Regulatory Choice Problem Gegenstand der Vorlesung. Zum Schluss werden das Konzept des Nudging und die bisherigen vielfältigen Anwendungen in der Politik vorgestellt und diskutiert. In diesem Block gibt es einen kurzen Einstieg in die experimentelle Ökonomik als ein Tool der institutionenökonomischen Analyse.

Neben der Vermittlung der oben genannten Theorien und Konzepte ist in jeder Vorlesung Platz für die kritische Diskussion mit den Studierenden. Zur weiteren kritischen Auseinandersetzung mit dem vermittelten Inhalt werden zwei Hausaufgaben gestellt. In diesen sollen zum einen bestimmte Konzepte wiedergegeben werden und zum anderen sollen diese in den aktuellen Forschungskontext einbezogen werden.

Prüfung: Klausur (90 Minuten) **Prüfungsvorleistungen:** Bearbeitung von zwei Hausaufgaben, von denen mindestens eine bestanden werden muss.	6 C
Prüfungsanforderungen: In der Klausur sollen die erlernten theoretischen Konzepte wiedergegeben, erklärt und kritische diskutiert bzw. reflektiert werden. Darüber hinaus müssen die Studierenden den Nachweis erbringen in der Lage zu sein diese theoretischen Konzepte auf aktuelle wirtschaftspolitische Fragestellungen anzuwenden.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Modul: B.WIWI-OPH.0007: Mikroökonomik I, Modul: B.WIWI-OPH.0008: Makroökonomik I"
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Kilian Bizer
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 3 - 6
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen **Module B.WIWI-VWL.0059: International Financial Markets**	6 C 4 WLH

Learning outcome, core skills: After a successful completion of the course students should be able to: • explain core relationships, which determine the behavior of the foreign exchange market. • argue on how exactly different macroeconomic variables interact and how it is reflected in the exchange rate. • evaluate various investment decisions based on their profitability. • assess the conditions, under which developed and developing countries cooperate on the international financial market.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Courses: **1. International Financial Markets** (Lecture) *Contents*: 1. Introduction to Exchange Rates Basic knowledge about nominal and nominal effective exchange rates. Arbitrage opportunities and equilibrium on the foreign exchange market. Covered interest rate parity and uncovered interest rate parity. Introduction to hedging. 2. Monetary Approach in the Long Run The law of one price and its applications. Real exchange rate, its definition and how it is derived from the purchasing power parity. Simple monetary model, the way price adjustments lead to a long-run equilibrium. Real interest rate and the exchange rate. 3. Asset Approach in the Short Run. Short run equilibrium on the money market and on the foreign exchange market. Nominal interest rate adjustment for keeping UIP in case of price rigidity. The relationship between domestic returns, foreign returns and the exchange rate, including overshooting. 4. Balance of Payments Gross national income, gross national expenditure, savings and investments in a closed/open economy. Current account and its components, capital account and financial account. Three approaches for measuring economic activity. Global imbalance and real world examples for it. 5. Gains from Financial Globalization. The concept of external wealth and how to compute it. The long-run budget constraint and the perpetual loan. Application of the budget constraint for developed and emerging economies. The idea behind consumption smoothing, shocks in closed and open economies. Efficient investment, financial openness and risk diversification. 6. Fixed and Floating Exchange Rate Regimes Fixed, crawling and floating exchange rates: advantages and drawbacks. How countries decide on a certain exchange rate regime. Economic similarity and the costs of asymmetric shocks. Fiscal discipline and inflation. Cooperative and non-cooperative adjustments to interest rates.	2 WLH

2. International Financial Markets (Exercise)	2 WLH
Contents:	
In the accompanying practice sessions students deepen and broaden their knowledge from the lectures.	

Examination: Written examination (90 minutes)	

Examination requirements:	
- Demonstrate a profound knowledge of the basic theoretical concepts in international finance. - Be able to assess decisions of a hypothetical investor/central banker and select the most profitable option. - Argue about gains from financial globalization and integration, using numerical and graphical analysis.	

Admission requirements:	**Recommended previous knowledge:**
none	Module B.WIWI-VWL.0007: Einführung in die Ökonometrie, Module B.WIWI-VWL.0004: Einführung in die Finanzwissenschaft, Module B.WIWI-OPH.0008: Makroökonomik I
Language:	**Person responsible for module:**
English	Prof. Dr. Tino Berger
Course frequency:	**Duration:**
irregular	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	3 - 5
Maximum number of students:	
not limited	

Georg-August-Universität Göttingen **Modul B.WIWI-WB.0005: Heterodoxie in der VWL** *English title: Heterodox Economics*	6 C 4 SWS

Lernziele/Kompetenzen: Nach Besuch der Veranstaltung sollten die Teilnehmer_innen dazu in der Lage sein, die unterschiedlichen Ansätze der Wirtschaftswissenschaften bewerten und aufeinander beziehen zu können. Dieser allgemeine Überblick soll ein Bewusstsein für Problembereiche der verschiedenen Ansätze zu schaffen und eine reflektierte Kontextualisierung ermöglichen.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltungen: **1. Heterodoxie in der VWL** (Vorlesung) *Inhalte*: Ziel der Veranstaltung ist die Betrachtung der Volkswirtschaftslehre aus einer pluralistischen Perspektive. Ausgehend von einer Standort-Bestimmung und einer geschichtlichen Fundierung der Ökonomik, soll die VWL wissenschaftstheoretisch durchleuchtet werden. Im Anschluss sollen alternative Herangehensweisen mit den klassischen Ansätzen kontrastiert werden und ihr Erklärungspotenzial kritisch hinterfragt werden.	2 SWS
2. Heterodoxie in der VWL (Tutorium)	2 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: Die Studierenden demonstrieren ein gutes Verständnis der im Unterricht präsentierten Inhalte. Sie sind in der Lage vorgestellte Theorien kritisch zu hinterfragen und sie in den Kontext der wissenschaftlichen Debatte einzuordnen.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Mikroökonomik I/II, Makroökonomik I/II
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Stephan Klasen Prof. Thomas Kneib
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 3 - 6
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-WIN.0001: Management der Informationssysteme** *English title: Management of Business Information Systems*	6 C 2 SWS

Lernziele/Kompetenzen: Nach erfolgreicher Teilnahme sind die Studierenden in der Lage, • die Phasen einer Anwendungssystementwicklung zu beschreiben sowie dortige Instrumente erläutern und anwenden zu können, • Vorgehensweisen, Ansätze und Werkzeuge zur Entwicklung von Anwendungssystemen zu beschreiben, gegenüberzustellen und vor dem Hintergrund gegebener Problemstellungen zu bewerten, • Elemente von Modellierungstechniken und Gestaltungsmöglichkeiten von Anwendungssystemen zu beschreiben und zu erläutern, • ausgewählte Methoden zur Modellierung von Anwendungssystemen selbstständig anwenden zu können, • Prinzipien der Anwendungssystementwicklung auf gegebene Problemstellungen transferieren zu können, • in Gruppenarbeit mit Hilfe angeeigneter Kommunikations- und Organisationsfähigkeiten Aufgabenstellungen im Themenfeld der Vorlesung zu bearbeiten.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden

Lehrveranstaltung: Management der Informationssysteme (Vorlesung) *Inhalte*: Die Veranstaltung Management der Informationssysteme (MIS) beschäftigt sich mit der produktorientierten Gestaltung der betrieblichen Informationsverarbeitung. Unter Produkt wird hier das Anwendungssystem bzw. eine ganze Landschaft aus Anwendungssystemen verstanden, die es zu gestalten, zu modellieren und zu organisieren gilt. Der Fokus der Veranstaltung liegt auf der Vermittlung von Vorgehensweisen sowie Methoden und konkreten Instrumenten, welche es erlauben, Anwendungssysteme logisch-konzeptionell zu gestalten. - Grundlagen der Systementwicklung • Herausforderungen bei der Einführung einer neuen Software • Vorgehensweisen zur Systementwicklung (z. B. Prototyping) • Grunds. Ansätze der Systementwicklung (z. B. Geschäftsprozessorientierter Ansatz) - Planung- und Definitionsphase • Methoden zur Systemplanung (z. B. Portfolio-Analyse) • Methoden zur System-Wirtschaftlichkeitsberechnung (z. B. Kapitalwertmethode) • Lastenhefte • Pflichtenhefte - Entwurfsphase • Geschäftsprozessmodell (z. B. Ereignisgesteuerte Prozessketten)	2 SWS

- Funktionsmodell (z. B. Anwendungsfall-Diagramm)
- Datenmodell (z. B. Entity-Relationship-Modell)
- Objektmodell (z. B. Klassendiagramm)
- Gestaltung der Benutzungsoberfläche (Prinzipien / Standards)
- Datenbankmodelle

- Implementierungsphase

- Prinzipien des Programmierens
- Arten von Programmiersprachen
- Übersetzungsprogramme
- Werkzeuge (z. B. Anwendungsserver)

- Abnahme- und Einführungsphase

- Qualitätssicherung (z. B. Systemtests)
- Prinzipien der Systemeinführung

- Wartungs- und Pflegephase

- Wartungsaufgaben
- Portfolio-Analyse

Prüfung: Klausur (90 Minuten) **Prüfungsvorleistungen:** Drei erfolgreich testierte Bearbeitungen von Fallstudien. **Prüfungsanforderungen:** Die Studierenden weisen in der Modulprüfung nach, dass sie • die in der Vorlesung vermittelten Aspekte der Anwendungssystementwicklung erläutern und beurteilen können, • Projekte zur Anwendungssystementwicklung in die vermittelten Phasen einordnen können, • Vorgehensweisen, Ansätze und Werkzeuge zur Entwicklung von Anwendungssystemen auf praktische Problemstellungen transferieren können, • komplexe Aufgabenstellungen mit Hilfe der vermittelten Inhalte analysieren und Lösungsansätze selbstständig aufzeigen können, • Vermittelte Methoden zur Modellierung von Anwendungssystemen notationskonform anwenden können und • in der Vorlesung vermittelten Ansätze auf vergleichbare Problemstellungen im Umfeld betrieblicher Anwendungssysteme übertragen können.	6 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Modul B.WIWI-OPH.0003: Informations- und Kommunikationssysteme
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Matthias Schumann
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 3 - 6

Maximale Studierendenzahl:	
nicht begrenzt	

Georg-August-Universität Göttingen **Modul B.WIWI-WIN.0002: Management der Informationswirtschaft** *English title: Fundamentals of Information Management*	6 C 6 SWS

Lernziele/Kompetenzen: Die Studierenden · kennen und verstehen strategische, operative und technische Aspekte des Informationsmanagements im Unternehmen. · kennen und verstehen verschiedene theoretische Modelle und Forschungsfelder des Informationsmanagements. · kennen und verstehen die Aufgaben des strategischen IT-Managements, der IT-Governance, des IT Controllings und des Sicherheits- sowie IT-Risk-Managements. · kennen und verstehen die Konzepte und Best-Practices im Informationsmanagement von Gastreferenten in deren Unternehmen. · analysieren und evaluieren Journal- und Konferenzbeiträge hinsichtlich wissenschaftlicher Fragestellungen. · analysieren und evaluieren praxisorientierte Fallstudien hinsichtlich des Beitrags des Informationsmanagements für den wirtschaftlichen Erfolg eines Unternehmens.	**Arbeitsaufwand:** Präsenzzeit: 84 Stunden Selbststudium: 96 Stunden

Lehrveranstaltungen:	
1. Management der Informationswirtschaft (Vorlesung)	2 SWS
2. Methodische Übung Management der Informationswirtschaft (Übung)	2 SWS
3. Inhaltliche Übung Management der Informationswirtschaft (Übung)	2 SWS

Prüfung: Klausur (90 Minuten) **Prüfungsvorleistungen:** Bearbeitung und Abgabe zweier Gruppenarbeiten im Rahmen der Übung. Nichtteilnahme/Abwesenheit bei der Erbringung von Prüfungsvorleistungen kann zum Ausschluss von der Prüfung führen.	

Prüfungsanforderungen: · Nachweis von Kenntnissen über Grundlagen der Informationswirtschaft. · Wissenschaftliche Bearbeitung von zwei Gruppenarbeiten in schriftlicher Form.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Orientierungsphase
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Lutz M. Kolbe
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 3

Maximale Studierendenzahl:	
nicht begrenzt	

Bemerkungen:
Das Modul wird in jedem Semester angeboten**.** Im Wintersemester wird die Vorlesung und Übung regulär gehalten. Im Sommersemester findet nur die Übung statt. Die Vorlesung ist im Selbststudium zu erarbeiten. Grundlage dafür ist die aufgezeichnete Vorlesung des jeweils vorhergehenden Wintersemesters.

Georg-August-Universität Göttingen	6 C
Modul M.Che.1311: Schwingungsspektroskopie und zwischenmolekulare Dynamik *English title: Vibrational Spectroscopy and Intermolecular Dynamics*	4 SWS

Lernziele/Kompetenzen:	Arbeitsaufwand:
• Die Absolventinnen und Absolventen dieses Moduls haben vertiefte theoretische Kenntnisse zur Schwingungsspektroskopie und zwischenmolekularen Dynamik, sowie deren Ausstrahlung auf andere Gebiete der Naturwissenschaften erworben und sind in der Lage, quantitative Fragestellungen dazu zu erfassen und zu lösen. • Insbesondere verstehen sie harmonische und anharmonische Kopplungen, Intensitätseffekte, fortgeschrittene Symmetrieaspekte und experimentelle Techniken der Schwingungsspektroskopie. • Sie können zwischenmolekulare Wechselwirkungen beschreiben, die sich daraus ergebenden Potentialhyperflächen, Aggregatstrukturen und dynamischen Phänomene analysieren und experimentelle Methoden der Spektroskopie von Molekülaggregaten vergleichen.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Vorlesung mit Übung: Schwingungsspektroskopie und zwischenmolekulare Dynamik	

Prüfung: Klausur (180 Minuten) **Prüfungsvorleistungen:** Aktive Teilnahme an den angebotenen Übungsstunden	6 C

Prüfungsanforderungen: Erfassung und quantitative Lösung von exemplarischen Fragestellungen aus dem Forschungsgebiet mit begrenzten Hilfsmitteln in vorgegebener Zeit, mindestens 50% der Sollpunktzahl.	

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Martin Suhm
Angebotshäufigkeit: i.d.Regel alle zwei jahre	**Dauer:** 1 Semester
Wiederholbarkeit: dreimalig	**Empfohlenes Fachsemester:** 1 - 2
Maximale Studierendenzahl: 64	

Georg-August-Universität Göttingen	6 C
Modul M.Che.1312: Physikalische Chemie der kondensierten Materie *English title: Physical Chemistry of Condensed Matter*	4 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Die Absolventinnen und Absolventen dieses Moduls haben vertiefte theoretische Kenntnisse zur Physikalischen Chemie fester Körper und deren Ausstrahlung auf andere Gebiete der Naturwissenschaften erworben und sind in der Lage, quantitative Fragestellungen dazu zu erfassen und zu lösen. Insbesondere haben die Studierenden die Grundlagen von strukturellen, mechanischen, thermischen, optischen, elektrischen und magnetischen Eigenschaften von Festkörpern, deren Dynamik und Phasenumwandlungsverhalten sowie die zugehörigen experimentellen Untersuchungsmethoden kennen gelernt.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Vorlesung mit Übung: Physikalische Chemie fester Körper *Angebotshäufigkeit:* in der Regel jedes 4. Semester	

Prüfung: Klausur (180 Minuten) **Prüfungsvorleistungen:** Aktive Teilnahme an den angebotenen Übungsstunden	6 C

Prüfungsanforderungen: Erfassung und quantitative Lösung von exemplarischen Fragestellungen aus dem Forschungsgebiet mit begrenzten Hilfsmitteln in vorgegebener Zeit, mindestens 50% der Sollpunktzahl.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Götz Eckold
Angebotshäufigkeit: in der Regel alle 2 jahre	**Dauer:** 1 Semester
Wiederholbarkeit: dreimalig	**Empfohlenes Fachsemester:** 1 - 2
Maximale Studierendenzahl: 64	

Georg-August-Universität Göttingen	6 C
Modul M.Che.1313: Elektronische Spektroskopie und Reaktionsdynamik	4 SWS
English title: Electronic Spectroscopy and Reaction Dynamics	

Lernziele/Kompetenzen:	Arbeitsaufwand:
Die Absolventinnen und Absolventen dieses Moduls haben vertiefte theoretische Kenntnisse zur elektronischen Spektroskopie und Reaktionsdynamik sowie deren Ausstrahlung auf andere Gebiete der Naturwissenschaften erworben und sind in der Lage, quantitative Fragestellungen dazu zu erfassen und zu lösen.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Vorlesung mit Übung: Elektronische Spektroskopie und Reaktionsdynamik	

Prüfung: Klausur (180 Minuten) Prüfungsvorleistungen: Aktive Teilnahme an den angebotenen Übungsstunden	6 C

Prüfungsanforderungen:	
Erfassung und quantitative Lösung von exemplarischen Fragestellungen aus dem Forschungsgebiet mit begrenzten Hilfsmitteln in vorgegebener Zeit, mindestens 50% der Sollpunktzahl.	

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: keine
Sprache: Deutsch, Englisch	Modulverantwortliche[r]: Prof. Dr. Alec Wodtke
Angebotshäufigkeit: i.d.Regel alle 2 jahre	Dauer: 1 Semester
Wiederholbarkeit: dreimalig	Empfohlenes Fachsemester: 1 - 2
Maximale Studierendenzahl: 64	

Georg-August-Universität Göttingen **Modul M.Che.1314: Biophysikalische Chemie** *English title: Biophysical Chemistry*	6 C 4 SWS

Lernziele/Kompetenzen: Nach erfolgreichem Abschluss des Moduls ... • sollen die Studierenden in der Lage sein, die wesentlichen physikochemischen Zusammenhänge biologischer Materie zu verstehen • die generellen Triebkräfte biologischer Reaktionen kennen • Spektroskopische Methoden zur Strukturbestimmung biologischer Makromoleküle verstehen und anwenden können • die Grundzüge moderner optischer Mikroskopie sowie der Sondenmikroskopie verstanden haben • die Mechanik und Dynamik biologischer Systeme ausgehend vom Einzelmolekül bis zur einzelnen Zelle erörtern können	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Vorlesung mit Übungen Biophysikalische Chemie	4 SWS

Prüfung: Klausur (120 Minuten)	6 C

Prüfungsanforderungen: • Strukturen biologischer Makromoleküle aus spektroskopischen und mikroskopischen Daten ableiten können • Übertragung genereller physikochemischer Prinzipien, wie zum Beispiel der Reaktionsdynamik, (statistischen) Thermodynamik und Quantentheorie auf die Beschreibung biologischer Phänomene • Kenntnisse der wesentlichen Methoden, wie z.B. Streumethoden, spektroskopische Methoden (UV-Vis, Fluoreszenz, Lumineszenz, Circulardichroismus ATR-IR, NMR, ESR, …), kalorimetrischen und kolligativen Methoden	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Andreas Janshoff
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: dreimalig	**Empfohlenes Fachsemester:** 1 - 2
Maximale Studierendenzahl: 64	

| Georg-August-Universität Göttingen | 6 C |
| Module M.Che.1315: Chemical Dynamics at Surfaces | 4 WLH |

| Learning outcome, core skills: | Workload: |
| The students of this module will achieve a deeper theoretical knowledge of chemical dynamics on surfaces as well as their influence on other fields in natural science, in order that they will be able to approach and solve problems regarding the quantitative questions in this field. | Attendance time: 56 h Self-study time: 124 h |

| Course: Lecture Combined with Tutorial: Chemical Dynamics at Surfaces | |

| Examination: Written examination (180 minutes) Examination prerequisites: Active participation in provided tutorial | 6 C |

| Examination requirements: | |
| By Understanding and solving exemplary questions regarding this research field with the help of limited reference material in predetermined time will count as minimum 50 % of the required score | |

Admission requirements:	Recommended previous knowledge:
none	none
Language:	Person responsible for module:
English	Prof. Dr. Alec Wodtke
Course frequency:	Duration:
normally every 2 years	1 semester[s]
Number of repeat examinations permitted:	Recommended semester:
three times	1 - 2
Maximum number of students:	
64	

Georg-August-Universität Göttingen **Modul M.Inf.1112: Effiziente Algorithmen** *English title: Efficient Algorithms*	5 C 3 SWS

Lernziele/Kompetenzen: Erwerb fortgeschrittener Kenntnisse und Fähigkeiten zur Entwicklung und Analyse effizienter Algorithmen und zur Untersuchung der Komplexität von Problemen in unterschiedlichen Anwendungsbereichen.	**Arbeitsaufwand:** Präsenzzeit: 42 Stunden Selbststudium: 108 Stunden

Lehrveranstaltung: Vorlesung/Übung *Inhalte*: Zum Beispiel: Randomisierte und Approximationsalgorithmen, Graphalgorithmen, Onlinealgorithmen, Netzwerkalgorithmen, Neurocomputing, Pattern-Matching-Algorithmen.	3 SWS
Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 25 Min.). **Prüfungsanforderungen:** Fähigkeit zum Entwurf von effizienten Algorithmen für gegebene Probleme. Beurteilungskompetenz von deren inherenter Komplexität in den Bereichen der Kerninformatik und ggf. ihren Anwendungen.	5 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm, Prof. Dr. Anita Schöbel, Prof. Dr. Florentin Andreas Wörgötter)
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 30	

Georg-August-Universität Göttingen **Modul M.Inf.1141: Semistrukturierte Daten und XML** *English title: Semistructured Data and XML*	6 C 4 SWS

Lernziele/Kompetenzen: 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.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Semistrukturierte Daten und XML (Vorlesung, Übung)	
Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 25 Min.) **Prüfungsanforderungen:** 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

Zugangsvoraussetzungen: Datenbanken	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Wolfgang May
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 100	

Georg-August-Universität Göttingen **Module M.Inf.1151: Specialisation Softwareengineering: Data Science and Big Data Analytics**	5 C 3 WLH

Learning outcome, core skills: The students • can define the terms data science, data scientist and big data, and acquire knowledge about the principle of data science and big data analytics • become acquainted with the life cycle of data science projects and know how the life cycle can be applied in practice • gain knowledge about a statistical and machine learning modelling system • gain knowledge about basic statistical tests and how to apply them • gain knowledge about clustering algorithms and how to apply them • gain knowledge about association rules and how to apply them • gain knowledge about regression techniques and how to apply them • gain knowledge about classification techniques and how to apply them • gain knowledge about text analysis techniques and how to apply them • gain knowledge about big data analytics with MapReduce • gain knowledge about advanced in-database analytics	**Workload:** Attendance time: 42 h Self-study time: 108 h

Course: Data Science and Big Data Analytics (Lecture, Exercise)	3 WLH
Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.) **Examination prerequisites:** Successful completion of 50% of each exercise and the conduction of a small analysis project. **Examination requirements:** Data science, big data, analytics, data science life cycle, statistical tests, clustering, association rules, regression, classification, text analysis, in-database analytics.	5 C

Admission requirements: none	**Recommended previous knowledge:** Foundations of statistics and stochastic.
Language: English	**Person responsible for module:** Prof. Dr. Jens Grabowski
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

Georg-August-Universität Göttingen	5 C
Module M.Inf.1171: Service-Oriented Infrastructures	3 WLH

Learning outcome, core skills:	**Workload:**
Successfully completing the module, students	Attendance time:
	42 h
• understand basic web technologies (transfer protocols, markup languages, markup processing, RESTful and SOAP web services)	Self-study time:
• understand virtualisation technologies (server, storage, and network virtualisation)	108 h
• understand Cloud computing (standards, APIs, management, service layers)	
• understand security mechanisms for distributed systems (authentication, authorisation, certificates, public key infrastructures)	
• understand data services (sharing, management, and analysis)	
• understand Big Data technology (MapReduce)	
On completion of this module students will have a good understanding of the fundamental and up-to-date concepts used in the context of service-oriented infrastructures. This basic knowledge can be leveraged by students to design, implement, and manage service-oriented infrastructures by themselves.	

Course: Service Computing (Lecture, Exercise)	3 WLH
Contents:	
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 such as Facebook, Google, or Amazon 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 such as Dropbox, Evernote, and iTunes. These examples and many more services build on sophisticated service-oriented infrastructures. The key challenges of service-oriented infrastructures are related to scaling services. More specifically large service-oriented 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. IT management covers Cloud computing, and the virtualisation of computing, storage, and network resources. Cloud computing in specific is covered by the discussion of production-grade infrastructure-as-service and platform-as-a-service middlewares.	
IT management is covered by the discussion of deployment models, service level agreements, and security aspects. Programming models are covered by discussing RESTful and SOAP web-services, MapReduce, and OSGi.	
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 service-oriented infrastructures.

Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.) **Examination requirements:** • RESTful and SOAP web services • XML • Compute, storage, and network virtualisation • Infrastructure-as-a-service, platform-as-a-service, software-as-a-service • Characteristics of Cloud computing (NIST) • OSGi • MapReduce • iRODS • Service level agreements • Symmetric and asymmetric encryption (SSL, TLS) • Security certificates (X.509) • Public key infrastructures	5 C

Admission requirements: none	Recommended previous knowledge: • Programming basics in Java or a similar language • Basic understanding of operating systems and command line interfaces
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.1172: Using Research Infrastructures**	5 C 3 WLH
Learning outcome, core skills: Successfully completing the module, students • understand what methods and services are available in state-of-the-art research infrastructures and direction of future development • understand the infrastructures for eScience and eResearch • know basics of data management and data analysis • know the fundamental of technologies like cloud computing and grids • understand the real-world problems from different domains (e.g., high energy physics, humanities, medical science, etc.) which are tackled by research infrastructures • understand certain aspects, methods and tools of these infrastructures for different use cases from different domains • will be motivated to take part in other related modules (e.g., Specialization in Distributed Systems, Parallel Computing, etc.)	**Workload:** Attendance time: 42 h Self-study time: 108 h
Course: Using Research Infrastructures - Examples from Humanities and Sciences (Lecture, Exercise) *Contents*: Successfully completing the lecture, students • understand the role and importance of the research infrastructure and their general building blocks • know the basics of grid computing • know the basics of cloud computing • learn basics on system virtualization • learn fundamental ideas of data management and analysis • understand the real-world problems from different domains (e.g., high energy physics, humanities, medical science/life science, etc.) which are tackled by research infrastructures • understand certain aspects, methods and tools of these infrastructures for different use cases from different domains • will be motivated to take part in other related modules (e.g., Specialization in Distributed Systems, Parallel Computing, etc.) • get familiar with real-world challenges through talks from experts who will present their current research activities and the role of research infrastructures on their research	3 WLH
Examination: Written examination (90 minutes) **Examination requirements:** Grid computing; cloud computing; system virtualization; data management; data analysis; application of eResearch infrastructure in high energy physics; eResearch in medicine and life science; eResearch in humanities	5 C

Admission requirements: none	**Recommended previous knowledge:** none
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: 30	

Georg-August-Universität Göttingen **Modul M.Inf.1181: Seminar NOSQL Databases** *English title: Seminar NOSQL Databases*	5 C 2 SWS

Lernziele/Kompetenzen: Erwerb fortgeschrittener theoretischer und praktischer Kompetenzen in ausgewählten Gebieten der NOSQL-Datenbanken. Ausbau der Fähigkeiten zur Präsentation und Beurteilung wissenschaftlicher Ergebnisse und zur wissenschaftlichen Diskussion.	Arbeitsaufwand: Präsenzzeit: 28 Stunden Selbststudium: 122 Stunden

Lehrveranstaltung: Seminar NOSQL Databases (Seminar) *Inhalte*: Erarbeitung aktueller Themen im Bereich NOSQL-Datenbanken anhand von wissenschaftlichen Arbeiten sowie praktischer Umgang mit einem NOSQL-Datenbanksystem.	2 SWS
Prüfung: Vortrag (ca. 45 Min.) mit schriftlicher Ausarbeitung (max. 10 Seiten) Prüfungsanforderungen: Eigenständiges Erarbeiten der Inhalte und Erstellen der Ausarbeitung sowie Halten des Vortrags.	5 C

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: keine
Sprache: Deutsch, Englisch	Modulverantwortliche[r]: Dr. Lena Wiese
Angebotshäufigkeit: unregelmäßig	Dauer: 1 Semester
Wiederholbarkeit: zweimalig	Empfohlenes Fachsemester:
Maximale Studierendenzahl: 14	

Georg-August-Universität Göttingen **Modul M.Inf.1182: Seminar Knowledge Engineering** *English title: Seminar Knowledge Engineering*	5 C 2 SWS

Lernziele/Kompetenzen: Erwerb fortgeschrittener Kompetenzen in ausgewählten Gebieten des Knowledge Engineering. Ausbau der Fähigkeiten zur Präsentation und Beurteilung wissenschaftlicher Ergebnisse und zur wissenschaftlichen Diskussion.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 122 Stunden

Lehrveranstaltung: Seminar Knowledge Engineering (Seminar) *Inhalte*: Erarbeitung aktueller Themen anhand von relevanten Originalarbeiten aus dem Bereich des Knowledge Engineering, der Datenmodellierung oder Wissensrepräsentation mit wechselnden Schwerpunkten (zum Beispiel Modellierung und Umsetzung von Datensicherheit oder Intelligente Informationssysteme).	2 SWS
Prüfung: Vortrag (ca. 45 Min.) mit schriftlicher Ausarbeitung (max. 10 Seiten) **Prüfungsanforderungen:** Eigenständiges Erarbeiten der Inhalte und Erstellen der Ausarbeitung sowie Halten des Vortrags.	5 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Dr. Lena Wiese
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 14	

Georg-August-Universität Göttingen **Module M.Inf.1185: Sensor Data Fusion**	5 C 3 WLH

Learning outcome, core skills:	**Workload:**
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 • explain the fundamentals of dynamic state estimation (including the Kalman filter) • formalize data fusion problems as state estimation problems • describe and model the most relevant sensors • define the most common discrete-time and continuous-time dynamic models • perform a time-discretization of continuous-time models • apply the Kalman filter to linear state estimation problems • explain and apply basic nonlinear estimation techniques such as the Extended Kalman filter (EKF) • assess the properties, advantages, and disadvantages of the discussed (nonlinear) estimators • deal with unknown correlations in data fusion • implement, simulate, and analyze data fusion problems in MATLAB • describe and implement basic algorithms for simultaneous localization and mapping (SLAM) in MATLAB • identify data fusion applications and assess the benefits of data fusion	**Attendance time:** 42 h **Self-study time:** 108 h

Course: Sensor Data Fusion (Lecture, Exercise)	3 WLH

Examination: Written exam (90 min.) or oral exam (approx. 20 min.) **Examination prerequisites:** Presentation of at least one exercise and active participation during the exercises. **Examination requirements:** Definition of data fusion; fundamentals of dynamic state estimation (including the Kalman filter); formalization of data fusion problems; typical sensor models; typical discrete-time and continuous-time dynamic models; discretization of continuous-time models; Extended Kalman filter (EKF); algorithms for dealing with unknown correlations in data fusion; basic algorithms for simultaneous localization and mapping (SLAM)	5 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Jun.-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:** Jun.-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	5 C
Module M.Inf.1187: Simulation-based Data Fusion and Analysis	3 WLH

Learning outcome, core skills:	**Workload:**
This module introduces fundamental simulation-based algorithms for the Bayesian fusion and analysis of noisy data sets. After completion, the students are able to • describe the Bayesian approach to data fusion and analysis • set up probabilistic state space models for time series data • describe the concept of a recursive Bayesian state estimator • employ Monte Carlo simulation for Bayesian inference • explain and apply sequential Monte Carlo methods, i.e., particle filters, such as Sequential Importance Sampling (SIS) and Sequential Importance Resampling (SIR) • explain and apply Markov Chain Monte Carlo (MCMC) methods such as Metropolis-Hasting and Gibbs sampling • describe the Bayesian interpretation of the Kalman filter • apply simulation-based implementations of the Kalman filter such as the Unscented Kalman Filter (UKF) and the Ensemble Kalman filter (EnKF) • employ Monte Carlo simulation for inference in probabilistic graphical models • explain Rao-Blackwellization and apply it to Simultaneous Localization and Mapping (SLAM) • assess the properties, advantages, and disadvantages of simulation-based techniques • apply the above concepts in the context of machine learning, computer vision, robotics, object tracking, and data science	Attendance time: 42 h Self-study time: 108 h

Course: Simulation-based Data Fusion and Analysis (Lecture, Exercise)	3 WLH

Examination: Written exam (90 min.) or oral exam (approx. 20 min.)	5 C
Examination prerequisites: Presentation of at least one exercise and active participation during the exercises. **Examination requirements:** Probabilistic state space models for time series data; recursive Bayesian state estimator; Monte Carlo simulation; Sequential Monte Carlo methods (particle filters); Sequential Importance Sampling (SIS) and Sequential Importance Resampling (SIR); Markov Chain Monte Carlo (MCMC) methods such as Metropolis-Hasting and Gibbs sampling; simulation-based implementations of the Kalman filter; Application of Monte Carlo simulation for inference in probabilistic graphical models; Rao-Blackwellization.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Jun.-Prof. Dr. Marcus Baum
Course frequency: irregular	**Duration:** 1 semester[s]

Number of repeat examinations permitted:	Recommended semester:
twice	
Maximum number of students:	
50	

Georg-August-Universität Göttingen	5 C
Modul M.Inf.1210: Seminar Algorithmische Methoden und theoretische Konzepte *English title: Seminar on Algorithmic Methods and Theoretical Concepts in Computer Science*	2 SWS

| **Lernziele/Kompetenzen:**
 Erwerb von Kompetenzen bei der selbständigen Erarbeitung und Präsentation von speziellen, forschungsbezogenen Themen zur Theoretischen Informatik und den Algorithmischen Methoden. Beispiele sind Probabilistische Datenmodelle, ihre mathematischen Grundlagen und ihre algorithmische Unterstützung, theoretische Grundlagen der Anwendung Informationstheoretischer Methoden in der Informatik, Methoden der Mustererkennung und des algorithmischen Lernens und ihrer Anwendungen.

 Überblick über die Modulinhalte:

 Aktuelle Originalarbeiten aus dem Bereich der theoretischen Informatik und algorithmischer Methoden. | **Arbeitsaufwand:**
 Präsenzzeit:
 28 Stunden
 Selbststudium:
 122 Stunden |

Lehrveranstaltung: Algorithmische Methoden und theoretische Konzepte (Seminar) *Inhalte*: Aktuelle Originalarbeiten aus dem Bereich der theoretischen Informatik und algorithmischer Methoden.	2 SWS
Prüfung: Vortrag (ca. 45 Min.) mit schriftlicher Ausarbeitung (max. 10 Seiten) **Prüfungsanforderungen:** Nachweis über den Erwerb von Kompetenzen bei der selbständigen Erarbeitung und Präsentation von forschungsbezogenen Themen zu den Algorithmischen Methoden und fortgeschrittenen theoretischen Konzepten in der Informatik oder einer der Angewandten Informatiken.	6 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 14	

Georg-August-Universität Göttingen **Modul M.Inf.1211: Probabilistische Datenmodelle und ihre Anwendungen** *English title: Probabilistic Data Models and Applications*	6 C 4 SWS

| **Lernziele/Kompetenzen:**
In dem Modul erwerben Studierende spezialisierte Kenntnisse zu Auswahl, Entwurf und Anwendungen von Modellen, für die die (parametrisierte) Zufälligkeit der Daten eine wesentliche Komponente der Modellierung ist.

Überblick über die Modulinhalte:

Zu verarbeitende Daten in verschiedensten Anwendungsbreichen (z. B. Bioinformatik) unterliegen meist statistischen Gesetzmäßigkeiten. Das Modul ist fokussiert auf Methoden zur Erkennung und algorithmischen Ausnutzung solcher typischen Muster durch geeignete probabilistische Modellierung der Daten und auf die Schätzung der Modellparameter.

z. B. Vorlesung Algorithmisches Lernen, Vorlesung Datenkompression und Informationstheorie, Probabilistische Datenmodelle in der Angewandten Informatik. | **Arbeitsaufwand:**
Präsenzzeit:
56 Stunden
Selbststudium:
124 Stunden |

Lehrveranstaltung: Vorlesungen, Übungen und Seminare zu den vorgenannten Themen	
Prüfung: Klausur (60 Min.) oder mündliche Prüfung (ca. 20 Min.) **Prüfungsanforderungen:** Nachweis über den Erwerb spezialisierter Kenntnisse und Fähigkeiten zu probabilistischen Datenmodellen, der Komplexität ihrer algorithmischen Unterstützung und ggf. ihrer Anwendung in einer der Angewandten Informatiken oder einem Anwendungsbereich.	6 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 30	

Georg-August-Universität Göttingen	6 C
Modul M.Inf.1213: Algorithmisches Lernen und Mustererkennung	4 SWS
English title: Algorithmic Learning and Pattern Recognition	

Lernziele/Kompetenzen:	Arbeitsaufwand:
Es werden spezialisierte Kompetenzen im Bereich des algorithmischen Lernens und der Mustererkennung vermittelt. Verständnis der theoretischen Grundlagen und der Probleme bei praktischen Anwendungen.	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Algorithmisches Lernen (Vorlesung, Übung)	4 SWS
Inhalte: Es werden die Grundlagen des Algorithmischen Lernens vermittelt, prinzipielle Schranken und Möglichkeiten aufgezeigt und einige spezielle Ansätze diskutiert wie z. B. Grundlagen des PAC-Lernens und des PAC-Lernens mit Rauschen auf der Klassifikation. Schlüsselbegriffe wie VC Dimension und Rademacher-Komplexität von Hypothesenklassen die es ermöglichen, sowohl Möglichkeiten als auch Grenzen der Lernbarkeit zu verstehen.	
Prüfung: Klausur (60 Min.) oder mündliche Prüfung (ca. 20 Min.) **Prüfungsanforderungen:** Nachweis über den Erwerb spezialisierter anwendungsorientierter Kenntnisse und Kompetenzen aus dem Bereich des algorithmischen Lernens und der Mustererkennung.	6 C

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 30	

Georg-August-Universität Göttingen	6 C
Modul M.Inf.1216: Datenkompression und Informationstheorie *English title: Data Compression and Information Theory*	4 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Die Studierenden • kennen den schematischen Aufbau von Kommunikationssystemen und verstehen ihre stochastischen/algorithmischen Beschreibungen • kennen die Grundbegriffe und Sätze der Shannonschen und der algorithmischen Informationstheorie und können sie in konkreten Situationen anwenden • kennen grundlegende verlustfreie Quellencodes (Huffman, Shannon, Lauflängen) und Erweiterungen sowie arithmetische Codes und können ihre Eignung in Anwendungssituationen bewerten • verstehen das Prinzip der Codeadaptionen und seine Implementierung anhand ausgewählter Codes • kennen allgemeine Entwurfsprinzipien für Quellencodes und verstehen ihre Umsetzung in konkreten Implementierungen • kennen die Schritte der verlustbehafteten Datenkompression und können ihre Leistungsparameter analysieren • kennen die Grundzüge der Ratenverzerrungstheorie und können sie in konkreten Situationen anwenden • kennen wichtige Beispiele verlustbehafteter Datenkompression, können sie analysieren und in Anwendungssituationen bewerten	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Datenkompression und Informationstheorie (Vorlesung, Übung)	4 SWS

| **Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.)**
 Prüfungsvorleistungen:
 Bearbeitung von 50% aller Übungsblätter, Vorführung mindestens einer Aufgabe während der Übung, kontinuierliche Teilnahme an den Übungen
 Prüfungsanforderungen:
 In der Prüfung wird die aktive Beherrschung der vermittelten Inhalte und Techniken nachgewiesen, z.B.

 • Verständnis der Zusammenhänge durch Umschreibung in eigenen Worten nachweisen
 • Konstruktion von Codes nach Vorgabe stochastischer Parameter
 • Schätzung stochastischer Parameter von Quellen und Kanälen
 • begründete Auswahl von Codierungsverfahren in hypothetischer Anwendungssituation
 • Codeparameter, Kanalkapazität etc. berechnen
 • (teilweise) programmtechnische Umsetzung von Quellen (de-)codierern
 • modulare Beschreibung konkreter Kommunikationssysteme darlegen
 • Leistungsparameter konkreter Quellencodierverfahren analysieren | 6 C |

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**

keine	Beherrschung einer Programmiersprache
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Carsten Damm
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 30	

Georg-August-Universität Göttingen **Module M.Inf.1231: Specialisation in Distributed Systems**	6 C 4 WLH

| **Learning outcome, core skills:**
Successfully completing the module, students

• have in-depth knowledge about one specific topical area of distributed systems
• understand the challenges of designing this specific part of a distributed system and integrating it into a larger infrastructure
• understand the tasks to operate this specific part of a distributed system within a modern data centre
• can apply their knowledge to evaluate application scenarios and make decisions regarding the applicability of certain technical solutions

Examples for specific topics are distributed architectures or distributed data and information management. | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

| **Course: Distributed Storage and Information Management** (Lecture, Exercise)
Contents:
Successfully completing the module, students

• understand how data and information can be stored and managed
• know the generic components of a modern data centre
• understand how to protect data using RAID and what RAID level to apply to what problem
• know about "intelligent" storage systems, including concepts like caching
• understand various storage networking technologies like Fibre Channel, iSCSI, and FCoE
• know about network-attached, object and unified storage
• basically understand how to achieve business continuity of storage systems
• understand the different backup and archiving technologies
• understand data replication
• have a basic understanding of storage virtualization
• know how to manage and how to secure storage infrastructures

Remark

With this lecture, we provide a preparation for the exam for the EMC Information Storage and Management Certificate. The Institute of Computer Science of the University of Göttingen is a Proven Professional of the EMC Academic Alliance.

References

S. Gnanasundaram, A. Shrivastava (eds.), Information Storage and Management, John Wiley & Sons, 2012. ISBN:978-1-118-09483-9 | 4 WLH |

| **Examination: Written exam (90 min.) or oral exam (ca. 20 min.)**
Examination prerequisites:
Solving and presenting at least one exercise (written solution and presentation), as well as active participation during the exercises. | 6 C |

Examination requirements:

Information Storage; Data Centre Environment and Components; RAID; Caching; Storage Provisioning; Fibre Channel; IP SAN; FCoE; Network-Attached Storage; Object-Based and Unified Storage; Backup and Archiving; Replication; Storage Cloud; Security in Storage Infrastructures; Management of Storage Infrastructures

Admission requirements: none	**Recommended previous knowledge:** • Computer architecture • Basic network protocols • Virtualisation techniques
Language: English	**Person responsible for module:** Prof. Dr. Ramin Yahyapour (Dr. Philipp Wieder)
Course frequency: unregelmäßig	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 30	

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

Learning outcome, core skills: Successfully completing the module, students are able to: • define and describe the benefit of parallel computing • specify the classification of parallel computers (Flyn classification) • analytically evaluate the performance of parallel computing approaches (scaling/ performance models) • know the parallel hardware and performance improvement approaches (cache coherence, pipeline, etc.) • know the interconnects and networks and their role in parallel computing • understand and develop sample parallel programs using different paradigms and development environments (e.g., shared memory and distributed models) • expose to some applications of Parallel Computing through hands-on exercises	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Parallel Computing (Lecture, Exercise) *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 **Modul M.Inf.1268: Informationstheorie** *English title: Information Theory*	6 C 4 SWS

Lernziele/Kompetenzen: Die Studierenden • kennen die mathematische Grundlagen der Informationstheorie • beherschen die grundlegenden Begriffe der Informationstheorie • beherrschen die zentralen Begriffe und Verfahren der Datenkompression • kennen grundlegende Begriffe und Aussagen zur Kanalkapazität • kennen grundlegende Begriffe und Aussagen zur Kolmogorov-Komplexität	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

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

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Stephan Waack
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 30	

Georg-August-Universität Göttingen	6 C
Module M.Inf.1281: NOSQL Databases	4 WLH

Learning outcome, core skills:	**Workload:**
Learning how to store arbitrary documents, objects of programming languages, XML data and graphs in native databases; and comparison to storing these data in relational databases. Getting to know novel requirements for database management systems like flexible update and query behavior and distributed data on multiple servers.	Attendance time: 56 h Self-study time: 124 h

Course: NOSQL Databases (Lecture, Exercise)	4 WLH
Contents: The lecture covers for example graph databases, object databases , XML databases, key-value stores, and column-based databases, as well as concepts of distributed data management.	

Examination: Written exam (90 minutes) or oral exam (approx. 20 minures) **Examination prerequisites:** Successful completion of a small database project (presentation and report) and active participation in the exercise sessions. **Examination requirements:** Presenting concepts, data models and storage mechanisms of the different NOSQL databases; explaining differences to the relational model. Showing basic knowledge of NOSQL query languages and access models. Explaining concepts of distributed database systems.	6 C

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Dr. Lena Wiese
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:**
Maximum number of students: 50	

Georg-August-Universität Göttingen **Modul M.Inf.1802: Praktikum XML** *English title: Practical Course on XML*	6 C 4 SWS

Lernziele/Kompetenzen: Die Studierenden verfügen über vertiefte Kenntnisse und Erfahrungen in Sprachen aus dem Bereich XML. Sie wissen, welche Sprachen und Werkzeuge ggf. bei Problemstellungen anwendbar sind und können Projekte in diesem Bereich umsetzen. Sie sind mit der Grundidee der W3C-Standards vertraut und können sich selber benötigte Informationen im Web zusammensuchen. Vermittlung von praktischen Fähigkeiten aus dem Bereich XML, XPath, XQuery, XSLT und weiteren Sprachen aus dem XML-Bereich	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Praktikum XML (Praktikum)	
Prüfung: Praktische Prüfung (ca. 4 Übungs- und Programmieraufgaben) und mündliche Prüfung (ca. 20 Min.) **Prüfungsanforderungen:** Vertiefte Kenntnisse und Erfahrungen in Sprachen aus dem Bereich XML. Kenntnisse darüber, welche Sprachen und Werkzeuge ggf. bei Problemstellungen anwendbar sind; Fähigkeit zum Umsetzen von Projekten in diesem Bereich; Kenntnisse des W3C-Standards; Fähigkeit zum Nachvollziehen wissenschaftlicher Fragestellungen und Vorgehensweisen.	6 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Wolfgang May
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 50	

Georg-August-Universität Göttingen **Modul M.Inf.1806: Projektseminar Datenbanken und Informations-systeme** *English title: Seminar and Project Databases*	6 C 2 SWS

Lernziele/Kompetenzen: 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.	**Arbeitsaufwand:** Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden

Lehrveranstaltung: Projektseminar Datenbanken und Informationssysteme	
Prüfung: Vortrag (ca. 60 Min.) mit schriftlicher Ausarbeitung (max. 25 Seiten) **Prüfungsanforderungen:** 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

Zugangsvoraussetzungen: Datenbanken	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch, Englisch	**Modulverantwortliche[r]:** Prof. Dr. Wolfgang May
Angebotshäufigkeit: unregelmäßig	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 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:	**Person responsible for module:**
English	Prof. Dr. Ramin Yahyapour
Course frequency:	**Duration:**
unregelmäßig	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	
Maximum number of students:	
20	

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 Paper, max. 50 pages (not counted appendices), alternatively, presentation (appr. 30 minutes) **Examination prerequisites:** Regular participation in the practical course	10 C

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

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

twice	Master: 1 - 3
Maximum number of students: not limited	
Additional notes and regulations: **Instructor:** Lecturers at the Institute of Numerical and Applied Mathematics	

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

Learning outcome, core skills:	**Workload:**
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.	Attendance time: 84 h Self-study time: 216 h

Course: Advanced practical course in stochastics (Internship)	6 WLH

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

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

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

Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.0971: Internship**	10 C (incl. key comp.: 10 C)

Learning outcome, core skills: After having successfully completed the module, students have competencies in project-oriented and research-oriented team work as well as in project management. They are familiar with methods, tools and processes of mathematics as well as the organisational and social environment in practice.	**Workload:** Attendance time: 0 h Self-study time: 300 h

Examination: Presentation (appr. 20 minutes) and written report (max. 10 pages), not graded **Examination prerequisites:** Certificate of the successful completion of the posed duties in accordance with the internship contract	10 C

Examination requirements: Successfully handling of the posed duties according to the internship contract between the student and the enterprise.	

Admission requirements: none	**Recommended previous knowledge:** none
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: each semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4; Promotion: 1 - 6
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers of the Unit Mathematics

Georg-August-Universität Göttingen **Module M.Mat.3110: Higher analysis**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

Weighted differently depending on the current course offer, after having successfully passed the module, students are familiar with basic principles of functional analysis respectively the description of linear elliptical differential equations in functional analysis. They

• are familiar with the most known examples of function and sequence spaces like spaces of continuous functions, Lp, lp and Sobolev spaces on bounded and unbounded areas;
• identify compactness of operators and analyse the solvability of general linear operator equations, especially of boundary value problems for linear elliptical differential equations with variable coefficients with the aid of the Riesz Fredholm theory;
• analyse the regularity of solutions of elliptical boundary value problems inside the domain in question and on its boundary;
• use basic theorems of linear operators in Banach spaces, especially the Banach-Steinhaus theorem, the Hahn-Banach theorem and the open mapping theorem;
• discuss weak convergence concepts and basic characteristics of dual and double-dual spaces;
• are familiar with basic concepts of spectral theory and the spectral theorem for bounded, self-adjoint operators.

Core skills:

After having successfully completed the module, students will be able to

• formulate and analyse differential equations and other problems in the language of functional analysis;
• identify and describe the relevance of characteristics of functional analysis like choice of a suitable function space, completeness, boundedness or compactness;
• evaluate the influence of boundary conditions and function spaces for existence, uniqueness and stability of solutions of differential equations. | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses: **1. Functional analysis / Partial differential equations** (Lecture)	4 WLH
2. Functional analysis / Partial differential equations - exercise session (Exercise)	2 WLH

Examination: Written examination (120 minutes) **Examination prerequisites:** M.Mat.3110.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements:	

Proof of the advanced knowledge about functional analysis or partial differential equations	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.0021, B.Mat.0022, B.Mat.1100
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
each summer semester	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Bachelor: 4 - 6; Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:
- **Instructor:** Lecturers at the Mathematical Institute or at the Institute of Numerical and Applied Mathematics
- **Written examination:** This module can be completed by taking a lecture course counting towards the modules B.Mat.2100 or B.Mat.2110. Compared to the exams of the modules B.Mat.2100 respectively B.Mat.2110, exams of the module "Higher analysis" have a higher level of difficulty and test advanced knowledge.
- **Exclusions:** The module "Higher analysis" cannot be completed by taking a lecture course that has already been accounted in the Bachelor's studies.

Georg-August-Universität Göttingen **Module M.Mat.3130: Operations research**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of the module enables students to learn methods, concepts, theories and applications in the area of the theory of operations research. Depending on the current course offer the following content-related competencies may be pursued. Students

• are able to identify problems of operations research in application-oriented problems and formulate them as optimisation problems;
• know methods for the modelling of application-oriented problems and are able to apply them;
• evaluate the target function included in a model and the side conditions on the basis of their particular important characteristics;
• analyse the complexity of the particular resulting optimisation problem;
• are able to develop optimisation methods for the solution of a problem of operation research or adapt general methods to special problems;
• know methods with which the quality of optimal solutions can be estimated to the upper and lower and apply them to the problem in question;
• differentiate between accurate solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing time;
• interpret the found solutions for the underlying practical problem and evaluate the model and solution method on this basis.

Core skills:

After having successfully completed the module, students will be able to

• discuss basic concepts of the area "Operations research";
• explain basic ideas of proof in the area "Operations research";
• identify typical applications in the area "Operations research". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination, appr. 20 minutes, alternatively written examination, 120 minutes **Examination prerequisites:** M.Mat.3130.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Successful proof of the acquired skills and competencies in the area "Operations research"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.2310
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
once a year	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.3140: Mathematical statistics**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** After having successfully completed the module "Mathematical statistics", students are familiar with the basic concepts and methods of mathematical statistics. They • understand most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and are able to use them in simple models of mathematical statistics; • evaluate statistical methods mathematically precisely, amongst others via suitable risk and loss concepts; • analyse optimality characteristics of statistical estimate methods via lower and upper bounds; • are familiar with basic statistical distribution models; • are familiar with references of mathematical statistics to other mathematical areas. **Core skills:** After having successfully completed the module, students have acquired basic competencies in mathematical statistics. They will be able to • apply statistical ways of thinking as well as basic mathematical methods of statistics; • formulate statistical models mathematical precisely; • analyse practical statistical problems mathematically precisely with the learned methods.	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Written examination, 120 minutes, alternatively, oral examination, appr. 20 minutes **Examination prerequisites:** M.Mat.3140.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Successful proof of the acquired skills and competencies in the area "Mathematical statistics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.1400
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:**

once a year	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.Mat.4511: Specialisation in analytic number theory**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods; • know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory; • are familiar with results and methods of prime number theory; • acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory; • know basic sieving methods and apply them to the problems of number theory; • know techniques used to estimate the sum of the sum of characters and of exponentials; • analyse the distribution of rational points on suitable algebraic varieties using analytical techniques; • master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory. **Core skills:** After having successfully completed the module, students will be able to • enhance concepts and methods for special problems and applications in the area "Analytic number theory"; • prepare substantial ideas of proof in the area "Analytic number theory".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Analytic number theory"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3311
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3311 "Advances in analytic number theory"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4512: Specialisation in analysis of partial differential equations**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - are familiar with the most important types of partial differential equations and know their solutions; - master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations; - are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations; - apply the basic principles of functional analysis to the solution of partial different equations; - use different theorems of function theory for solving partial different equations; - master different asymptotic techniques to study characteristics of the solutions of partial different equations; - are paradigmatically familiar with broader application areas of linear theory of partial different equations; - are paradigmatically familiar with broader application areas of non-linear theory of partial different equations; - know the importance of partial different equations in the modelling in natural and engineering sciences; - master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis. **Core skills:** After having successfully completed the module, students will be able to - enhance concepts and methods for special problems and applications in the area "Analysis of partial differential equations"; - prepare substantial ideas of proof in the area "Analysis of partial differential equations".	Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C

Examination prerequisites:

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions

Examination requirements:

Proof of the acquisition of special skills and the mastery of special knowledge in the area "Analysis of partial differential equations"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3312
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3312 "Advances in analysis of partial differential equations"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4513: Specialisation in differential geometry**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• master the basic concepts of differential geometry;
• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;
• develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability";
• master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory;
• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;
• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;
• are able to import geometrical problems to a broader mathematical and physical context.

Core skills:

After having successfully completed the module, students will be able to

• enhance concepts and methods for special problems and applications in the area "Differential geometry";
• prepare substantial ideas of proof in the area "Differential geometry". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
Examination requirements:	

Proof of the acquisition of special skills and the mastery of special knowledge in the area "Differential geometry"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3313
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3313 "Advances in variational analysis"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4514: Specialisation in algebraic topology**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	84 h Self-study time: 186 h
Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students	

- know the basic concepts of set-theoretic topology and continuous mappings;
- construct new topologies from given topologies;
- know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;
- apply basic concepts of category theory to topological spaces;
- use concepts of functors to obtain algebraic invariants of topological spaces and mappings;
- know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;
- know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems;
- calculate homology and cohomology with the aid of chain complexes;
- deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;
- become acquainted with connections between analysis and topology;
- apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Algebraic topology";
- prepare substantial ideas of proof in the area "Algebraic topology".

Courses: **1. Lecture course** (Lecture)	4 WLH

2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic topology"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3314
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3314 "Advances in algebraic topology"	**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 Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module M.Mat.4515: Specialisation in mathematical methods in physics	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	Self-study time: 186 h
The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are	
• harmonic analysis, algebraic structures and representation theory, (group) effects; • operator algebra, C* algebra and von-Neumann algebra; • operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions; • (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.	
One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves.	
Core skills:	
After having successfully completed the module, students will be able to	
• enhance concepts and methods for special problems and applications in the area "Mathematical methods of physics"; • prepare substantial ideas of proof in the area "Mathematical methods of physics".	

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Mathematical methods in physics"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3315

Language:	Person responsible for module:
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3315 "Advances in mathematical methods in physics"	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 Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module M.Mat.4521: Specialisation in algebraic geometry	6 WLH

Learning outcome, core skills:	Workload:
Learning outcome:	Attendance time:
	84 h
In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	Self-study time: 186 h

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students

- are familiar with commutative algebra, also in greater detail;
- know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
- examine important examples like elliptic curves, Abelian varieties or algebraic groups;
- use divisors for classification questions;
- study algebraic curves;
- prove the Riemann-Roch theorem and apply it;
- use cohomological concepts and know the basics of Hodge theory;
- apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
- classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
- get to know connections to complex analysis and to complex geometry.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Algebraic geometry"";
- prepare substantial ideas of proof in the area "Algebraic geometry"".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites:	

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions

Examination requirements:
Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic geometry"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3321

Language:	**Person responsible for module:**
English	Programme coordinator

Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3321 "Advances in algebraic geometry"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4522: Specialisation in algebraic number theory**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students - know Noetherian and Dedekind rings and the class groups; - are familiar with discriminants, differents and bifurcation theory of Hilbert; - know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL); - are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues; - know densities, the Tchebotarew theorem and applications; - work with orders, S-integers and S-units; - know the class field theory of Hilbert, Takagi and Idele theoretical field theory; - are familiar with Zp-extensions and their Iwasawa theory; - discuss the most important hypotheses of Iwasawa theory and their consequences. Concerning algorithmic aspects of number theory, the following competencies are pursued. Students - work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors; - are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests; - use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics; - discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields; - calculate class groups and fundamental units; - calculate Galois groups of absolute number fields. **Core skills:** After having successfully completed the module, students will be able to - enhance concepts and methods for special problems and applications in the area "Algebraic number theory"; - prepare substantial ideas of proof in the area "Algebraic number theory".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic number theory"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3322
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3322 "Advances in algebraic number theory"	**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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4523: Specialisation in algebraic structures**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students • know basic concepts like rings, modules, algebras and Lie algebras; • know important examples of Lie algebras and algebras; • know special classes of Lie groups and their special characteristics; • know classification theorems for finite-dimensional algebras; • apply basic concepts of category theory to algebras and modules; • know group actions and their basic classifications; • apply the enveloping algebra of Lie algebras; • apply ring and module theory to basic constructs of algebraic geometry; • use combinatorial tools for the study of associative algebras and Lie algebras; • acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups; • know Hopf algebras as well as their deformation and representation theory. **Core skills:** After having successfully completed the module, students will be able to • enhance concepts and methods for special problems and applications in the area "Algebraic structures"; • prepare substantial ideas of proof in the area "Algebraic structures".	**Attendance time:** 84 h **Self-study time:** 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:**	9 C

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic structures"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3323
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3323 "Advances in algebraic structures"	**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 Mathematical Institute	

Georg-August-Universität Göttingen **Module M.Mat.4524: Specialisation in groups, geometry and dynamical systems**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** In the modules of the cycle "Groups, geometry and dynamical systems" students get to know the most important classes of groups as well as the algebraic, geometrical and analytical tools that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Group theory uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of the area "Groups, geometry and dynamical systems" that supplement one another complementarily. The following content-related competencies are pursued. Students • know basic concepts of groups and group homomorphisms; • know important examples of groups; • know special classes of groups and their special characteristics; • apply basic concepts of category theory to groups and define spaces via universal properties; • apply the concepts of functors to obtain algebraic invariants; • know group actions and their basic classification results; • know the basics of group cohomology and compute these for important examples; • know the basics of geometrical group theory like growth characteristics; • know self-similar groups, their basic constructs as well as examples with interesting characteristics; • use geometrical and combinatorial tools for the study of groups; • know the basics of the representation theory of compact Lie groups. **Core skills:** After having successfully completed the module, students will be able to • enhance concepts and methods for special problems and applications in the area "Groups, geometry and dynamical systems"; • prepare substantial ideas of proof in the area "Groups, geometry and dynamical systems".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C

Examination prerequisites:

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions

Examination requirements:

Proof of the acquisition of special skills and the mastery of special knowledge in the area "Groups, geometry and dynamical systems"

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3324
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3324 "Advances in groups, geometry and dynamical systems"	**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 Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module M.Mat.4525: Specialisation in non-commutative geometry	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
In the modules of the cycle "Non-commutative geometry" students get to know the conception of space of non-commutative geometry and some of its applications in geometry, topology, mathematical physics, the theory of dynamical systems and number theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	Self-study time: 186 h

Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued. Students

- are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;
- construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;
- know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it;
- know important examples of simple C*-algebras and deduce their basic characteristics;
- apply basic concepts of category theory to C*-algebras;
- model the symmetries of non-commutative spaces;
- apply Hilbert modules in C*-algebras;
- know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it;
- apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;
- compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;
- classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;
- classify W*-algebras and know the intrinsic dynamic of factors;
- apply von Neumann algebras to the axiomatic formulation of quantum field theory;
- use von Neumann algebras for the construction of L2 invariants for manifolds and groups;
- understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups;
- define the invariants of algebras and modules with chain complexes and their homology and calculate these;

- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Non-commutative geometry";
- prepare substantial ideas of proof in the area "Non-commutative geometry".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Non-commutative geometry"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3325
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3325 "Advances in non-commutative geometry"	**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 Mathematical Institute

Georg-August-Universität Göttingen	9 C
Module M.Mat.4531: Specialisation in inverse problems	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	84 h
The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 186 h

- are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;
- evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors;
- analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;
- analyse the convergence of regularisation methods with the help of complex analysis;
- analyse regularisation methods from stochastic error models;
- apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;
- model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region;
- analyse the uniqueness and conditional stability of inverse problems of partial differential equations;
- deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;
- formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Inverse problems";
- prepare substantial ideas of proof in the area "Inverse problems".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Inverse problems"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3331
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3331 "Advances in inverse problems"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4532: Specialisation in approximation methods**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;
• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;
• know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions;
• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;
• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
• evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time;
• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;
• are informed about current developments of efficient data approximation and data analysis;
• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.

Core skills:

After having successfully completed the module, students will be able to

• enhance concepts and methods for special problems and applications in the area "Approximation methods";
• prepare substantial ideas of proof in the area "Approximation methods". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses: **1. Lecture course** (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites:	
Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements:	
Proof of the acquisition of special skills and the mastery of special knowledge in the area "Approximation methods"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3332
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3332 "Advances in approximation methods"	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.4533: Specialisation in numerical methods of partial differential equations**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution; • know the basics of the theory of linear integral equations; • are familiar with basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM); • analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems; • apply methods for adaptive lattice refinement on the basis of a posteriori error approximations; • know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation; • apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems; • apply available software for the solution of partial differential equations and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations; • know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods. **Core skills:** After having successfully completed the module, students will be able to • enhance concepts and methods for special problems and applications in the area "Numerics of partial differential equations";	**Attendance time:** 84 h **Self-study time:** 186 h

- prepare substantial ideas of proof in the area "Numerics of partial differential equations".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Numerical methods of partial differential equations"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3333
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3333 "Advances in numerical methods of partial differential equations"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4534: Specialisation in optimisation**	9 C 6 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • identify optimisation problems in application-oriented problems and formulate these as mathematical programmes; • evaluate the existence and uniqueness of the solution of an optimisation problem; • identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set; • know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised; • analyse the complexity of an optimisation problem; • classify a mathematical programme in a class of optimisation problems and know current solution strategies for it; • develop optimisation methods and adapt general methods to special problems; • deduce upper and lower bounds for optimisation problems and understand their meaning; • understand the geometrical structure of an optimisation problem and apply it for solution strategies; • distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times; • acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation; • acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning; • handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems. **Core skills:** After having successfully completed the module, students will be able to • enhance concepts and methods for special problems and applications in the area "Optimisation"; • prepare substantial proof ideas in the area "Optimisation".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Optimisation"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3334
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3334 "Advances in optimisation"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4537: Specialisation in variational analysis**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:**	**Workload:** Attendance time: 84 h Self-study time: 186 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in variational analysis and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;
- master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems;
- understand basic concepts of the convergence of sets and continuity of set-valued functions;
- understand basic concepts of variational geometry;
- calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;
- understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;
- analyse constrained and parametric optimisation problems with the help of duality theory;
- calculate and use the Legendre-Fenchel transformation and infimal convulutions;
- formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;
- apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;
- understand the connection between convex functions and monotone operators;
- examine the convergence of fixed point iterations with the help of the theory of monotone operators;
- deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;
- apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;
- model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;
- know applications of control theory and apply methods of dynamic programming;
- use tools of variational analysis in image processing and with inverse problems;
- know basic concepts and methods of stochastic optimisation.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Variational analysis";
- prepare substantial ideas of proof in the area "Variational analysis".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Variational analysis"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3337
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3337 "Advances in variational analysis"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen	9 C
Module M.Mat.4538: Specialisation in image and geometry processing	6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e.g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h
	Self-study time:
	186 h

- are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;
- learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;
- learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;
- learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;
- acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;
- know basic concepts and methods of topology;
- are familiar with visualisation software;
- apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
- know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;
- evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;
- are informed about current developments of efficient geometrical and topological data analysis;
- adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Image and geometry processing";
- prepare substantial ideas of proof in the area "Image and geometry processing".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Image and geometry processing"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3338
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3338 "Advances in image and geometry processing"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4539: Specialisation in scientific computing / applied mathematics**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Scientific computing / applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions; • know basic methods for the numerical solution of these models; • analyse stability, convergence and efficiency of numerical solution strategies; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware; • use methods of scientific computing for solving application problems, like e. g. of natural and business sciences. **Core skills:** After having successfully completed the module, students will be able to • enhance concepts and methods for special problems and applications in the area "Scientific computing / applied mathematics"; • prepare substantial ideas of proof in the area "Scientific computing / applied mathematics".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Scientific computing / applied mathematics	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3339
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module B.Mat.3339 "Advances in scientific computing / applied mathematics"	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.4541: Specialisation in applied and mathematical stochastics**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 84 h
The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students	Self-study time: 186 h

- are familiar with advanced concepts of probability theory established on measure theory and apply them independently;
- are familiar with substantial concepts and approaches of probability modelling and inferential statistics;
- know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;
- have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;
- understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;
- analyse the convergence characteristic of stochastic processes;
- analyse regularity characteristics of the paths of stochastic processes;
- adequately model temporal and spatial phenomena in natural and economicsciences as stochastic processes, if necessary with unknown parameters;
- analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed;
- discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Applied and mathematical stochastics";
- prepare substantial ideas of proof in the area "Applied and mathematical stochastics".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Applied and mathematical stochastics"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3341
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3341 "Advances in applied and mathematical stochastics"	**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.Mat.4542: Specialisation in stochastic processes**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with advanced concepts of probability theory established on measure theory and apply them independently; • know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces; • understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes; • know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes; • analyse regularity characteristics of the paths of stochastic processes; • construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics; • are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms; • analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems; • formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics; • are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes; • know fundamental convergence theorems for stochastic processes and generalise these; • model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes; • analyse models in mathematical economics and finance and understand evaluation methods for financial products. **Core skills:** After having successfully completed the module, students will be able to	**Workload:** Attendance time: 84 h Self-study time: 186 h

- enhance concepts and methods for special problems and applications in the area "Stochastic processes";
- prepare substantial ideas of proof in the area "Stochastic processes".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Stochastic processes"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3342
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3342 "Advances in stochastic processes	**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.Mat.4543: Specialisation in stochastic methods in econo-mathematics**	9 C 6 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - master problems, basic concepts and stochastic methods of economathematics; - understand stochastic connections; - understand references to other mathematical areas; - get to know possible applications in theory and practice; - gain insight into the connection of mathematics and economic sciences. **Core skills:** After having successfully completed the module, students will be able to - enhance concepts and methods for special problems and applications in the area "Stochastic methods of economathematics"; - prepare substantial ideas of proof in the area "Stochastic methods of economathematics".	**Workload:** Attendance time: 84 h Self-study time: 186 h

Courses: **1. Lecture course** (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Stochastic methods in economathematics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3343
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:** 1 semester[s]

Usually subsequent to the module B.Mat.3343 "Advances in stochastic methods in economathematics"	
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.Mat.4544: Specialisation in mathematical statistics**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics;
• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;
• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;
• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;
• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;
• know different techniques to obtain lower and upper risk bounds in these models;
• are confident in modelling typical data structures of regression;
• analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand;
• are able to mathematically analyse resampling methods and apply them purposively;
• are familiar with advanced tools of non-parametric statistics and empirical process theory;
• independently become acquainted with a current topic of mathematical statistics;
• evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

• enhance concepts and methods for special problems and applications in the area "Variational analysis";
• prepare substantial ideas of proof in the area "Variational analysis". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes)	9 C
Examination prerequisites: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	

Examination requirements:	
Proof of the acquisition of special skills and the mastery of special knowledge in the area "Mathematical statistics"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3344
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3344 "Advances in mathematical statistics"	**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	9 C
Module M.Mat.4545: Specialisation in statistical modelling and inference	6 WLH

Learning outcome, core skills:	Workload:
Learning outcome:	Attendance time: 84 h
The successful completion of modules of the cycle "Statistical modelling and inference" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 186 h

- are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation;
- are familiar with the tools of asymptotic statistical inference;
- learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;
- are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;
- become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;
- are able to develop and mathematically evaluate complex statistical models for real data problems.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Statistical modelling and inference";
- prepare substantial ideas of proof in the area "Statistical modelling and inference".

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Statistical modelling and inference"	

Admission requirements:	Recommended previous knowledge:

none	B.Mat.3345
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3345 "Advances in statistical modelling and inference"	**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.Mat.4546: Specialisation in multivariate statistics**	9 C 6 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications;
• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;
• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;
• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;
• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;
• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;
• are confident to apply resampling methods to non-Euclidean descriptors;
• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;
• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;
• are familiar with concepts of large scale computational statistical techniques;
• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;
• evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

• enhance concepts and methods for special problems and applications in the area "Multivariate statistics";
• prepare substantial ideas of proof in the area "Multivariate statistics". | **Workload:**
Attendance time:
84 h
Self-study time:
186 h |

Courses:	
1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Multivariate statistics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3346
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3346 "Advances in multivariate statistics"	**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.Mat.4547: Specialisation in statistical foundations of data science**	9 C 6 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	84 h Self-study time: 186 h

- are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications;
- evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;
- analyse characteristics of statistical estimation methods via lower and upper information bounds;
- are familiar with basic statistical distribution models that base on the theory of exponential families;
- are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies
- analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand;
- are able to mathematically analyse resampling methods and apply them purposively;
- are familiar with concepts of large scale computational statistical techniques;
- are familiar with advanced tools of non-parametric statistics and empirical process theory;
- independently become acquainted with a current topic of statistical data science;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- enhance concepts and methods for special problems and applications in the area "Statistical foundations of data science";
- prepare substantial ideas of proof in the area "Statistical foundations of data science".

Courses:

1. Lecture course (Lecture)	4 WLH
2. Exercise session (Exercise)	2 WLH

Examination: Oral examination (approx. 20 minutes) **Examination prerequisites:** Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C

Examination requirements: Proof of the acquisition of special skills and the mastery of special knowledge in the area "Statistical foundations of data science"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3347
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module B.Mat.3347 "Advances in statistical foundations of data science"	**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.Mat.4611: Aspects of analytic number theory**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods; • know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory; • are familiar with results and methods of prime number theory; • acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory; • know basic sieving methods and apply them to the problems of number theory; • know techniques used to estimate the sum of the sum of characters and of exponentials; • analyse the distribution of rational points on suitable algebraic varieties using analytical techniques; • master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Analytic number theory"; • carry out scientific work under supervision in the area "Analytic number theory".	56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Analytic number theory"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3311
Language: English	**Person responsible for module:** Programme coordinator

Course frequency:	Duration:
Usually subsequent to the module M.Mat.4511 "Specialisation in analytic number theory"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4612: Aspects of analysis of partial differential equations**	6 C 4 WLH

| Learning outcome, core skills:
Learning outcome:

The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the most important types of partial differential equations and know their solutions;
• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;
• are familiar with the theory of generalized functions and the theory of function spaces and use these for solving differential partial equations;
• apply the basic principles of functional analysis to the solution of partial different equations;
• use different theorems of function theory for solving partial different equations;
• master different asymptotic techniques to study characteristics of the solutions of partial different equations;
• are paradigmatically familiar with broader application areas of linear theory of partial different equations;
• are paradigmatically familiar with broader application areas of non-linear theory of partial different equations;
• know the importance of partial different equations in the modelling in natural and engineering sciences;
• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Analysis of partial differential equations";
• carry out scientific work under supervision in the area "Analysis of partial differential equations". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:	
Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Analysis of partial differential equations"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3312
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4512 "Specialisation in analysis of partial differential equations"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4613: Aspects of differential geometry**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - master the basic concepts of differential geometry; - develop a spatial sense using the examples of curves, areas and hypersurfaces; - develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability"; - master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory; - develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods; - acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems; - are able to import geometrical problems to a broader mathematical and physical context. **Core skills:** After having successfully completed the module, students will be able to - conduct scholarly debates about problems of the area "Differential geometry"; - carry out scientific work under supervision in the area "Differential geometry".	Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Differential geometry"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3313
Language:	**Person responsible for module:**

English	Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4513 "Specialisation in differential geometry"	**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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4614: Aspects of algebraic topology**	6 C 4 WLH
Learning outcome, core skills: **Learning outcome:** In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students • know the basic concepts of set-theoretic topology and continuous mappings; • construct new topologies from given topologies; • know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds; • apply basic concepts of category theory to topological spaces; • use concepts of functors to obtain algebraic invariants of topological spaces and mappings; • know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them; • know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems; • calculate homology and cohomology with the aid of chain complexes; • deduce algebraic characteristics of homology and cohomology with the aid of homological algebra; • become acquainted with connections between analysis and topology; • apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Algebraic topology"; • carry out scientific work under supervision in the area "Algebraic topology".	**Workload:** Attendance time: 56 h Self-study time: 124 h
Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:	
Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic topology"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3314
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4514 "Specialisation in algebraic topology"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4615: Aspects of mathematical methods in physics**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are

• harmonic analysis, algebraic structures and representation theory, (group) effects;
• operator algebra, C* algebra and von-Neumann algebra;
• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;
• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.

One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Mathematical methods of physics";
• carry out scientific work under supervision in the area "Mathematical methods of physics". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Mathematical methods in physics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3315
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:** 1 semester[s]

Usually subsequent to the module M.Mat.4515 "Specialisation in mathematical methods in physics"	
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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4621: Aspects of algebraic geometry**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students

• are familiar with commutative algebra, also in greater detail;
• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
• examine important examples like elliptic curves, Abelian varieties or algebraic groups;
• use divisors for classification questions;
• study algebraic curves;
• prove the Riemann-Roch theorem and apply it;
• use cohomological concepts and know the basics of Hodge theory;
• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
• get to know connections to complex analysis and to complex geometry.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Algebraic geometry"";
• carry out scientific work under supervision in the area "Algebraic geometry"". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:	

Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic geometry"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3321
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4521 "Specialisation in algebraic geometry"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4622: Aspects of algebraic number theory**	6 C 4 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students - know Noetherian and Dedekind rings and the class groups; - are familiar with discriminants, differents and bifurcation theory of Hilbert; - know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL); - are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues; - know densities, the Tchebotarew theorem and applications; - work with orders, S-integers and S-units; - know the class field theory of Hilbert, Takagi and Idele theoretical field theory; - are familiar with Zp-extensions and their Iwasawa theory; - discuss the most important hypotheses of Iwasawa theory and their consequences. Concerning algorithmic aspects of number theory, the following competencies are pursued. Students - work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors; - are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests; - use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics; - discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields; - calculate class groups and fundamental units; - calculate Galois groups of absolute number fields. **Core skills:** After having successfully completed the module, students will be able to - conduct scholarly debates about problems of the area "Algebraic number theory"; - carry out scientific work under supervision in the area "Algebraic number theory".	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic number theory"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3322
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4522 "Specialisation in algebraic number theory"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4623: Aspects of algebraic structures**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students

• know basic concepts like rings, modules, algebras and Lie algebras;
• know important examples of Lie algebras and algebras;
• know special classes of Lie groups and their special characteristics;
• know classification theorems for finite-dimensional algebras;
• apply basic concepts of category theory to algebras and modules;
• know group actions and their basic classifications;
• apply the enveloping algebra of Lie algebras;
• apply ring and module theory to basic constructs of algebraic geometry;
• use combinatorial tools for the study of associative algebras and Lie algebras;
• acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups;
• know Hopf algebras as well as their deformation and representation theory.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Algebraic structures";
• carry out scientific work under supervision in the area "Algebraic structures". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic structures"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3323
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4523 "Specialisation in Variational Analysis"	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 Mathematical Institute

Georg-August-Universität Göttingen	6 C
Module M.Mat.4624: Aspects of groups, geometry and dynamical systems	4 WLH

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

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Groups, geometry and dynamical systems" students get to know the most important classes of groups as well as the algebraic, geometrical and analytical tools that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Group theory uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of the area "Groups, geometry and dynamical systems" that supplement one another complementarily. The following content-related competencies are pursued. Students

- know basic concepts of groups and group homomorphisms;
- know important examples of groups;
- know special classes of groups and their special characteristics;
- apply basic concepts of category theory to groups and define spaces via universal properties;
- apply the concepts of functors to obtain algebraic invariants;
- know group actions and their basic classification results;
- know the basics of group cohomology and compute these for important examples;
- know the basics of geometrical group theory like growth characteristics;
- know self-similar groups, their basic constructs as well as examples with interesting characteristics;
- use geometrical and combinatorial tools for the study of groups;
- know the basics of the representation theory of compact Lie groups.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Groups, geometry and dynamical systems";
- carry out scientific work under supervision in the area "Groups, geometry and dynamical systems".

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

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:	

Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Groups, geometry and dynamical systems"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3324
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4524 "Specialisation in groups, geometry and dynamical systems"	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4625: Aspects of non-commutative geometry**	6 C 4 WLH

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

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Non-commutative geometry" students get to know the conception of space of non-commutative geometry and some of its applications in geometry, topology, mathematical physics, the theory of dynamical systems and number theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued. Students

- are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;
- construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;
- know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it;
- know important examples of simple C*-algebras and deduce their basic characteristics;
- apply basic concepts of category theory to C*-algebras;
- model the symmetries of non-commutative spaces;
- apply Hilbert modules in C*-algebras;
- know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it;
- apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;
- compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;
- classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;
- classify W*-algebras and know the intrinsic dynamic of factors;
- apply von Neumann algebras to the axiomatic formulation of quantum field theory;
- use von Neumann algebras for the construction of L2 invariants for manifolds and groups;
- understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups;
- define the invariants of algebras and modules with chain complexes and their homology and calculate these;

- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Non-commutative geometry";
- carry out scientific work under supervision in the area "Non-commutative geometry".

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Non-commutative geometry"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3325
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4525 "Specialisation in non-commutative geometry"	**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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4631: Aspects of inverse problems**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;
• evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors;
• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;
• analyse the convergence of regularisation methods with the help of complex analysis;
• analyse regularisation methods from stochastic error models;
• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;
• model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region;
• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;
• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;
• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Inverse problems";
• carry out scientific work under supervision in the area "Inverse problems". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:	
Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Inverse problems"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3331

Language:	Person responsible for module:
English	Programme coordinator

Course frequency:	Duration:
Usually subsequent to the module M.Mat.4531 "Specialisation in inverse problems"	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.4632: Aspects of approximation methods**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;
• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;
• know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions;
• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;
• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
• evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time;
• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;
• are informed about current developments of efficient data approximation and data analysis;
• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Approximation methods";
• carry out scientific work under supervision in the area "Approximation methods". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Approximation methods"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3332
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4532 "Specialisation in approximation methods"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4633: Aspects of numerical methods of partial differential equations**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution; - know the basics of the theory of linear integral equations; - are familiar with the basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM); - analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems; - apply methods for adaptive lattice refinement on the basis of a posteriori error approximations; - know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation; - apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems; - apply available software for the solution of partial differential equations and evaluate the results sceptically; - evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; - acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations; - know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods. **Core skills:** After having successfully completed the module, students will be able to - conduct scholarly debates about problems of the area "Numerics of partial differential equations";	Attendance time: 56 h Self-study time: 124 h

- carry out scientific work under supervision in the area "Numerics of partial differential equations".

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Numerical methods of partial differential equations"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3333
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4533 "Specialisation in numerical methods of partial differential equations"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4634: Aspects of optimisation**	6 C 4 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • identify optimisation problems in application-oriented problems and formulate these as mathematical programmes; • evaluate the existence and uniqueness of the solution of an optimisation problem; • identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set; • know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised; • analyse the complexity of an optimisation problem; • classify a mathematical programme in a class of optimisation problems and know current solution strategies for it; • develop optimisation methods and adapt general methods to special problems; • deduce upper and lower bounds for optimisation problems and understand their meaning; • understand the geometrical structure of an optimisation problem and apply it for solution strategies; • distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times; • acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation; • acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning; • handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Optimisation"; • carry out scientific work under supervision in the area "Optimisation".	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Optimisation"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3334
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4534 "Specialisation in optimisation"	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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen	6 C
Module M.Mat.4637: Aspects of variational analysis	4 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	56 h
The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in variational analysis and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 124 h

- understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;
- master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems;
- understand basic concepts of the convergence of sets and continuity of set-valued functions;
- understand basic concepts of variational geometry;
- calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;
- understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;
- analyse constrained and parametric optimisation problems with the help of duality theory;
- calculate and use the Legendre-Fenchel transformation and infimal convulutions;
- formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;
- apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;
- understand the connection between convex functions and monotone operators;
- examine the convergence of fixed point iterations with the help of the theory of monotone operators;
- deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;
- apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;
- model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;
- know applications of control theory and apply methods of dynamic programming;
- use tools of variational analysis in image processing and with inverse problems;
- know basic concepts and methods of stochastic optimisation.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Variational analysis";
- carry out scientific work under supervision in the area "Variational analysis".

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Variational analysis".	

Admission requirements: none	Recommended previous knowledge: B.Mat.3337
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4537 "Specialisation in Variational Analysis"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4638: Aspects of image and geometry processing**	6 C 4 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces; • learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces; • learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform; • learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces; • acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies; • know basic concepts and methods of topology; • are familiar with visualisation software; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • know which special characteristics of an image or of a geometry can be extracted and worked on with which methods; • evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data; • are informed about current developments of efficient geometrical and topological data analysis; • adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Image and geometry processing"; • carry out scientific work under supervision in the area "Image and geometry processing".	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Image and geometry processing"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3338
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4538 "Specialisation in image and geometry processing"	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4639: Aspects of scientific computing / applied mathematics**	6 C 4 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Scientific computing / Applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / Applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions; • know basic methods for the numerical solution of these models; • analyse stability, convergence and efficiency of numerical solution strategies; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware; • use methods of scientific computing for solving application problems, like e. g. of natural and business sciences. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Scientific computing / Applied mathematics"; • carry out scientific work under supervision in the area "Scientific computing / Applied mathematics".	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Scientific computing / applied mathematics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3339
Language:	**Person responsible for module:**

English	Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4539 "Specialisation in scientific computing / applied mathematics"	**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 Numerical and Applied Mathematics	

Georg-August-Universität Göttingen **Module M.Mat.4641: Aspects of applied and mathematical stochastics**	6 C 4 WLH

Learning outcome, core skills:	Workload:
Learning outcome: The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students • are familiar with advanced concepts of probability theory established on measure theory and apply them independently; • are familiar with substantial concepts and approaches of probability modelling and inferential statistics; • know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness; • have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples; • understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy; • analyse the convergence characteristic of stochastic processes; • analyse regularity characteristics of the paths of stochastic processes; • adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters; • analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed; • discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Applied and mathematical stochastics"; • carry out scientific work under supervision in the area "Applied and mathematical stochastics".	Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:

Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Applied and mathematical stochastics"

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3341
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4541 "Specialisation in applied and mathematical stochastics"	**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 | 6 C |
| Module M.Mat.4642: Aspects of stochastic processes | 4 WLH |

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

The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with advanced concepts of probability theory established on measure theory and apply them independently;
- know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;
- understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;
- know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes;
- analyse regularity characteristics of the paths of stochastic processes;
- construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;
- are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms;
- analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems;
- formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;
- are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;
- know fundamental convergence theorems for stochastic processes and generalise these;
- model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;
- analyse models in mathematical economics and finance and understand evaluation methods for financial products.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Stochastic processes";

- carry out scientific work under supervision in the area "Stochastic processes".

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Stochastic processes"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3342
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4542 "Specialisation in stochastic processes"	**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.Mat.4643: Aspects of stochastics methods of economathematics**	6 C 4 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master problems, basic concepts and stochastic methods of economathematics; • understand stochastic connections; • understand references to other mathematical areas; • get to know possible applications in theory and practice; • gain insight into the connection of mathematics and economic sciences. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Stochastic methods of economathematics"; • carry out scientific work under supervision in the area "Stochastic methods of economathematics".	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Stochastics methods of economathematics"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3343
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4543 "Specialisation in stochastics methods of economathematics"	**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.Mat.4644: Aspects of mathematical statistics**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics;
• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;
• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;
• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;
• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;
• know different techniques to obtain lower and upper risk bounds in these models;
• are confident in modelling typical data structures of regression;
• analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand;
• are able to mathematically analyse resampling methods and apply them purposively;
• are familiar with advanced tools of non-parametric statistics and empirical process theory;
• independently become acquainted with a current topic of mathematical statistics;
• evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Mathematical statistics";
• carry out scientific work under supervision in the area "Mathematical statistics". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:

Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Mathematical statistics"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3344
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4544 "Specialisation in mathematical statistics"	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 Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Mat.4645: Aspects of statistical modelling and inference**	6 C 4 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Statistical modelling and inference" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation;
• are familiar with the tools of asymptotic statistical inference;
• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;
• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;
• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;
• are able to develop and mathematically evaluate complex statistical models for real data problems.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Statistical modelling and inference";
• carry out scientific work under supervision in the area "Statistical modelling and inference". | **Workload:**
Attendance time:
56 h
Self-study time:
124 h |

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Statistical modelling and inference"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3345
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:**

Usually subsequent to the module M.Mat.4545 "Specialisation in statistical modelling and inference"	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.Mat.4646: Aspects of multivariate statistics	6 C 4 WLH

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

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications;
- can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;
- are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;
- are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;
- are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;
- analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;
- are confident to apply resampling methods to non-Euclidean descriptors;
- are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;
- have a fundamental knowledge of statistics of point processes and Bayesian methods involved;
- are familiar with concepts of large scale computational statistical techniques;
- independently become acquainted with a current topic of multivariate and non-Euclidean statistics;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Multivariate statistics";
- carry out scientific work under supervision in the area "Multivariate statistics".

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements:	
Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Multivariate statistics"	

Admission requirements:	Recommended previous knowledge:
none	M.Mat.4546
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
Usually subsequent to the module M.Mat.4546 "Specialisation in multivariate statistics"	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 Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Mat.4647: Aspects of statistical foundations of data science**	6 C 4 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications; • evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts; • analyse characteristics of statistical estimation methods via lower and upper information bounds; • are familiar with basic statistical distribution models that base on the theory of exponential families; • are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies • analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand; • are able to mathematically analyse resampling methods and apply them purposively; • are familiar with concepts of large scale computational statistical techniques; • are familiar with advanced tools of non-parametric statistics and empirical process theory; • independently become acquainted with a current topic of statistical data science; • evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Statistical foundations of data science"; • carry out scientific work under supervision in the area "Statistical foundations of data science".	**Attendance time:** 56 h **Self-study time:** 124 h

Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH

Examination: Oral examination (approx. 20 minutes)	6 C

Examination requirements: Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Statistical foundations of data science"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4547
Language: English	Person responsible for module: Programme coordinator
Course frequency: Usually subsequent to the module M.Mat.4547 "Specialisation in statistical foundations of data science"	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.Mat.4711: Special course in analytic number theory**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;
know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;
are familiar with results and methods of prime number theory;
acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;
know basic sieving methods and apply them to the problems of number theory;
know techniques used to estimate the sum of the sum of characters and of exponentials;
analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;
master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.
Core skills:

After having successfully completed the module, students will be able to

conduct scholarly debates about problems of the area "Analytic number theory"; become acquainted with special problems in the area "Analytic number theory" to carry out scientific work for it. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Analytic number theory"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3311
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:**

not specified	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4712: Special course in analysis of partial differential equations**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the most important types of partial differential equations and know their solutions;
• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;
• are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;
• apply the basic principles of functional analysis to the solution of partial different equations;
• use different theorems of function theory for solving partial different equations;
• master different asymptotic techniques to study characteristics of the solutions of partial different equations;
• are paradigmatically familiar with broader application areas of linear theory of partial different equations;
• are paradigmatically familiar with broader application areas of non-linear theory of partial different equations;
• know the importance of partial different equations in the modelling in natural and engineering sciences;
• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Analysis of partial differential equations";
• become acquainted with special problems in the area "Analysis of partial differential equations" to carry out scientific work for it. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Analysis of partial differential equations"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3312

Language:	Person responsible for module:
English	Programme coordinator

Course frequency:	Duration:
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4713: Special course in differential geometry**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master the basic concepts of differential geometry; • develop a spatial sense using the examples of curves, surfaces and hypersurfaces; • develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability"; • master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory; • develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods; • acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems; • are able to import geometrical problems to a broader mathematical and physical context. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Differential geometry"; • become acquainted with special problems in the area "Differential geometry" to carry out scientific work for it.	Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Differential geometry"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3313

Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4714: Special course in algebraic topology**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:**	**Workload:** Attendance time: 28 h Self-study time: 62 h

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students

- know the basic concepts of set-theoretic topology and continuous mappings;
- construct new topologies from given topologies;
- know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;
- apply basic concepts of category theory to topological spaces;
- use concepts of functors to obtain algebraic invariants of topological spaces and mappings;
- know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;
- know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems;
- calculate homology and cohomology with the aid of chain complexes;
- deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;
- become acquainted with connections between analysis and topology;
- apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Algebraic topology";
- become acquainted with special problems in the area "Algebraic topology" to carry out scientific work for it.

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic topology"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3314
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen	3 C
Module M.Mat.4715: Special course in mathematical methods in physics	2 WLH

Learning outcome, core skills:	Workload:
Learning outcome:	Attendance time:
In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	28 h Self-study time: 62 h

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are

- harmonic analysis, algebraic structures and representation theory, (group) effects;
- operator algebra, C* algebra and von-Neumann algebra;
- operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;
- (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.

One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Mathematical methods of physics";
- become acquainted with special problems in the area "Mathematical methods of physics" to carry out scientific work for it.

Workload:

Attendance time:
28 h
Self-study time:
62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Mathematical methods in physics"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3315
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4721: Special course in algebraic geometry**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students

• are familiar with commutative algebra, also in greater detail;
• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
• examine important examples like elliptic curves, Abelian varieties or algebraic groups;
• use divisors for classification questions;
• study algebraic curves;
• prove the Riemann-Roch theorem and apply it;
• use cohomological concepts and know the basics of Hodge theory;
• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
• get to know connections to complex analysis and to complex geometry.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Algebraic geometry";
• become acquainted with special problems in the area "Algebraic geometry" to carry out scientific work for it. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic geometry"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3321
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4722: Special course in algebraic number theory**	3 C 2 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students • know Noetherian and Dedekind rings and the class groups; • are familiar with discriminants, differents and bifurcation theory of Hilbert; • know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL); • are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues; • know densities, the Tchebotarew theorem and applications; • work with orders, S-integers and S-units; • know the class field theory of Hilbert, Takagi and Idele theoretical field theory; • are familiar with Zp-extensions and their Iwasawa theory; • discuss the most important hypotheses of Iwasawa theory and their consequences. Concerning algorithmic aspects of number theory, the following competencies are pursued. Students • work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors; • are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests; • use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics; • discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields; • calculate class groups and fundamental units; • calculate Galois groups of absolute number fields. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Algebraic number theory"; • become acquainted with special problems in the area "Algebraic number theory" to carry out scientific work for it.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic number theory	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3322
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**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 Mathematical Institute

Georg-August-Universität Göttingen	3 C
Module M.Mat.4723: Special course in algebraic structures	2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h
In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	Self-study time: 62 h
Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students	
• know basic concepts like rings, modules, algebras and Lie algebras; • know important examples of Lie algebras and algebras; • know special classes of Lie groups and their special characteristics; • know classification theorems for finite-dimensional algebras; • apply basic concepts of category theory to algebras and modules; • know group actions and their basic classifications; • apply the enveloping algebra of Lie algebras; • apply ring and module theory to basic constructs of algebraic geometry; • use combinatorial tools for the study of associative algebras and Lie algebras; • acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups; • know Hopf algebras as well as their deformation and representation theory.	
Core skills:	
After having successfully completed the module, students will be able to	
• conduct scholarly debates about problems of the area "Algebraic structures"; • become acquainted with special problems in the area "Algebraic structures" to carry out scientific work for it.	

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic structures"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3323
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4724: Special course in groups, geometry and dynamical systems**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: In the modules of the cycle "Groups, geometry and dynamical systems" students get to know the most important classes of groups as well as the algebraic, geometrical and analytical tools that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Group theory uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of the area "Groups, geometry and dynamical systems" that supplement one another complementarily. The following content-related competencies are pursued. Students • know basic concepts of groups and group homomorphisms; • know important examples of groups; • know special classes of groups and their special characteristics; • apply basic concepts of category theory to groups and define spaces via universal properties; • apply the concepts of functors to obtain algebraic invariants; • know group actions and their basic classification results; • know the basics of group cohomology and compute these for important examples; • know the basics of geometrical group theory like growth characteristics; • know self-similar groups, their basic constructs as well as examples with interesting characteristics; • use geometrical and combinatorial tools for the study of groups; • know the basics of the representation theory of compact Lie groups. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Groups, geometry and dynamical systems"; • become acquainted with special problems in the area "Groups, geometry and dynamical systems" to carry out scientific work for it.	Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Groups, geometry and dynamical systems"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3324
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Institute

Georg-August-Universität Göttingen	3 C
Module M.Mat.4725: Special course in non-commutative geometry	2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	28 h
In the modules of the cycle "Non-commutative geometry" students get to know the	Self-study time:
conception of space of non-commutative geometry and some of its applications in	62 h

Learning outcome, core skills:

Learning outcome:

In the modules of the cycle "Non-commutative geometry" students get to know the conception of space of non-commutative geometry and some of its applications in geometry, topology, mathematical physics, the theory of dynamical systems and number theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued. Students

- are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;
- construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;
- know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it;
- know important examples of simple C*-algebras and deduce their basic characteristics;
- apply basic concepts of category theory to C*-algebras;
- model the symmetries of non-commutative spaces;
- apply Hilbert modules in C*-algebras;
- know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it;
- apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;
- compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;
- classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;
- classify W*-algebras and know the intrinsic dynamic of factors;
- apply von Neumann algebras to the axiomatic formulation of quantum field theory;
- use von Neumann algebras for the construction of L2 invariants for manifolds and groups;
- understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups;
- define the invariants of algebras and modules with chain complexes and their homology and calculate these;

- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Non-commutative geometry";
- become acquainted with special problems in the area "Non-commutative geometry" to carry out scientific work for it.

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Non-commutative geometry"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3325
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**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 Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4731: Special course in inverse problems**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;
• evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors;
• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;
• analyse the convergence of regularisation methods with the help of complex analysis;
• analyse regularisation methods from stochastic error models;
• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;
• model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region;
• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;
• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;
• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Inverse problems";
• become acquainted with special problems in the area "Inverse problems" to carry out scientific work for it. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Inverse problems"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3331
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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.4732: Special course in approximation methods**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces; • can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces; • know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions; • acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data; • are informed about current developments of efficient data approximation and data analysis; • adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Approximation methods"; • become acquainted with special problems in the area "Approximation methods" to carry out scientific work for it.	Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Approximation methods"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3332
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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.4733: Special course in numerical methods of partial differential equations**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution; • know the basics of the theory of linear integral equations; • are familiar with basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM); • analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems; • apply methods for adaptive lattice refinement on the basis of a posteriori error approximations; • know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation; • apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems; • apply available software for the solution of partial differential equations and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations; • know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Variational analysis"; • become acquainted with special problems in the area "Variational analysis" to carry out scientific work for it.	28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area Numerical nethods of partial differential equations"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3333
Language: English	Person responsible for module: Programme coordinator
Course frequency: not specified	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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4734: Special course in optimisation**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • identify optimisation problems in application-oriented problems and formulate these as mathematical programmes; • evaluate the existence and uniqueness of the solution of an optimisation problem; • identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set; • know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised; • analyse the complexity of an optimisation problem; • classify a mathematical programme in a class of optimisation problems and know current solution strategies for it; • develop optimisation methods and adapt general methods to special problems; • deduce upper and lower bounds for optimisation problems and understand their meaning; • understand the geometrical structure of an optimisation problem and apply it for solution strategies; • distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times; • acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation; • acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning; • handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Optimisation"; • become acquainted with special problems in the area "Optimisation" to carry out scientific work for it.	**Attendance time:** 28 h **Self-study time:** 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Optimisation"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3334
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: on an irregular basis	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4737: Special course in variational analysis**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in variational analysis and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	**Workload:** Attendance time: 28 h Self-study time: 62 h

- understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;
- master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems;
- understand basic concepts of the convergence of sets and continuity of set-valued functions;
- understand basic concepts of variational geometry;
- calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;
- understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;
- analyse constrained and parametric optimisation problems with the help of duality theory;
- calculate and use the Legendre-Fenchel transformation and infimal convulutions;
- formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;
- apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;
- understand the connection between convex functions and monotone operators;
- examine the convergence of fixed point iterations with the help of the theory of monotone operators;
- deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;
- apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;
- model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;
- know applications of control theory and apply methods of dynamic programming;
- use tools of variational analysis in image processing and with inverse problems;
- know basic concepts and methods of stochastic optimisation.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Variational analysis";
- become acquainted with special problems in the area "Variational analysis" to carry out scientific work for it.

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Variational analysis"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3337
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen **Module M.Mat.4738: Special course in image and geometry processing**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces; • learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces; • learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform; • learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces; • acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies; • know basic concepts and methods of topology; • are familiar with visualisation software; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • know which special characteristics of an image or of a geometry can be extracted and worked on with which methods; • evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data; • are informed about current developments of efficient geometrical and topological data analysis; • adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Image and geometry processing";	**Workload:** Attendance time: 28 h Self-study time: 62 h

- become acquainted with special problems in the area "Image and geometry processing" to carry out scientific work for it.

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Image and geometry processing"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3338
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**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 Numerical and Applied Mathematics

Georg-August-Universität Göttingen	3 C
Module M.Mat.4739: Special course in scientific computing / applied mathematics	2 WLH

Learning outcome, core skills:	Workload:
Learning outcome:	Attendance time: 28 h
The successful completion of modules of the cycle "Scientific computing / applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 62 h

- are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;
- know basic methods for the numerical solution of these models;
- analyse stability, convergence and efficiency of numerical solution strategies;
- apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
- evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;
- are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;
- use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.

Core skills:

After having successfully completed the module, students will be able to

- conduct scholarly debates about problems of the area "Scientific computing / applied mathematics";
- become acquainted with special problems in the area "Scientific computing / applied mathematics" to carry out scientific work for it.

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Scientific computing / applied mathematics"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3339

Language:	Person responsible for module:
English	Programme coordinator

Course frequency:	**Duration:**
not specified	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.4741: Special course in applied and mathematical stochastics**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students

• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;
• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;
• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;
• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;
• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;
• analyse the convergence characteristic of stochastic processes;
• analyse regularity characteristics of the paths of stochastic processes;
• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;
• analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed;
• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Applied and mathematical stochastics";
• become acquainted with special problems in the area "Applied and mathematical stochastics" to carry out scientific work for it. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Applied and mathematical stochastics"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3341
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Statistics

Georg-August-Universität Göttingen **Module M.Mat.4742: Special course in stochastic processes**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with advanced concepts of probability theory established on measure theory and apply them independently; • know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces; • understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes; • know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes; • analyse regularity characteristics of the paths of stochastic processes; • construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics; • are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms; • analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems; • formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics; • are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes; • know fundamental convergence theorems for stochastic processes and generalise these; • model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes; • analyse models in mathematical economics and finance and understand evaluation methods for financial products. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Stochastic processes";	**Workload:** Attendance time: 28 h Self-study time: 62 h

- become acquainted with special problems in the area "Stochastic processes" to carry out scientific work for it.

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Stochastic processes"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3342
Language: English	Person responsible for module: Programme coordinator
Course frequency: not specified	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 Statistics

Georg-August-Universität Göttingen **Module M.Mat.4743: Special course in stochastic methods of econo-mathematics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - master problems, basic concepts and stochastic methods of economathematics; - understand stochastic connections; - understand references to other mathematical areas; - get to know possible applications in theory and practice; - gain insight into the connection of mathematics and economic sciences. **Core skills:** After having successfully completed the module, students will be able to - conduct scholarly debates about problems of the area "Stochastic methods of economathematics"; - become acquainted with special problems in the area "Stochastic methods of economathematics" to carry out scientific work for it.	Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Stochastic methods of economathematics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3343
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**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 Statistics

Georg-August-Universität Göttingen **Module M.Mat.4744: Special course in mathematical statistics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics; • evaluate statistical methods mathematically precisely via suitable risk and loss concepts; • analyse optimality characteristics of statistical estimate methods via lower and upper bounds; • analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory; • are familiar with basic statistical distribution models that base on the theory of exponential indexed families; • know different techniques to obtain lower and upper risk bounds in these models; • are confident in modelling typical data structures of regression; • analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand; • are able to mathematically analyse resampling methods and apply them purposively; • are familiar with advanced tools of non-parametric statistics and empirical process theory; • independently become acquainted with a current topic of mathematical statistics; • evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Mathematical statistics"; • become acquainted with special problems in the area "Mathematical statistics" to carry out scientific work for it.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Mathematical statistics"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3344

Language:	Person responsible for module:
English	Programme coordinator

Course frequency:	Duration:
not specified	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 Mathematical Statistics

Georg-August-Universität Göttingen **Module M.Mat.4745: Special course in statistical modelling and inference**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Statistical modelling and inference" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation;
• are familiar with the tools of asymptotic statistical inference;
• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;
• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;
• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;
• are able to develop and mathematically evaluate complex statistical models for real data problems.

Core skills:

After having successfully completed the module, students will be able to

• conduct scholarly debates about problems of the area "Statistical modelling and inference";
• become acquainted with special problems in the area "Statistical modelling and inference" to carry out scientific work for it. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements: Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Statistical modelling and inference"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3345
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:**

not specified	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 Statistics

Georg-August-Universität Göttingen **Module M.Mat.4746: Special course in multivariate statistics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications; • can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling; • are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models; • are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis; • are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae; • analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions; • are confident to apply resampling methods to non-Euclidean descriptors; • are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines; • have a fundamental knowledge of statistics of point processes and Bayesian methods involved; • are familiar with concepts of large scale computational statistical techniques; • independently become acquainted with a current topic of multivariate and non-Euclidean statistics; • evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Multivariate statistics"; • become acquainted with special problems in the area "Multivariate statistics" to carry out scientific work for it.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Multivariate statistics"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3346
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Statistics

Georg-August-Universität Göttingen **Module M.Mat.4747: Special course in statistical foundations of data science**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications; • evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts; • analyse characteristics of statistical estimation methods via lower and upper information bounds; • are familiar with basic statistical distribution models that base on the theory of exponential families; • are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies • analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand; • are able to mathematically analyse resampling methods and apply them purposively; • are familiar with concepts of large scale computational statistical techniques; • are familiar with advanced tools of non-parametric statistics and empirical process theory; • independently become acquainted with a current topic of statistical data science; • evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to • conduct scholarly debates about problems of the area "Statistical foundations of data science"; • become acquainted with special problems in the area "Statistical foundations of data science" to carry out scientific work for it.	28 h Self-study time: 62 h

Course: Lecture course (Lecture)	2 WLH

Examination: Oral examination (approx. 20 minutes)	3 C

Examination requirements:	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Statistical foundations of data science"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3347
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	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 Mathematical Statistics

| Georg-August-Universität Göttingen | 3 C |
| Module M.Mat.4811: Seminar on analytic number theory | 2 WLH |

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h
The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 62 h

- solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;
- know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;
- are familiar with results and methods of prime number theory;
- acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;
- know basic sieving methods and apply them to the problems of number theory;
- know techniques used to estimate the sum of the sum of characters and of exponentials;
- analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;
- master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Analytic number theory" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Analytic number theory"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3311
Language:	**Person responsible for module:**

English	Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4812: Seminar on analysis of partial differential equations**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	28 h
The successful completion of modules of the cycle "Analysis of partial differential	Self-study time:
equations" enables students to learn methods, concepts, theories and applications	62 h
in the area "Analysis of partial differential equations". During the course of the cycle	
students will be successively introduced to current research topics and able to carry	
out independent contributions to research (e. g. within the scope of a Master's thesis).	
Depending on the current course offer the following content-related competencies may	
be pursued. Students	

- are familiar with the most important types of partial differential equations and know their solutions;
- master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;
- are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;
- apply the basic principles of functional analysis to the solution of partial different equations;
- use different theorems of function theory for solving partial different equations;
- master different asymptotic techniques to study characteristics of the solutions of partial different equations;
- are paradigmatically familiar with broader application areas of linear theory of partial different equations;
- are paradigmatically familiar with broader application areas of non-linear theory of partial different equations;
- know the importance of partial different equations in the modelling in natural and engineering sciences;
- master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Analysis of partial differential equations" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues in the area "Analysis of partial differential equations"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3312
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4813: Seminar on differential geometry**	3 C 2 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master the basic concepts of differential geometry; • develop a spatial sense using the examples of curves, surfaces and hypersurfaces; • develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability"; • master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory; • develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods; • acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems; • are able to import geometrical problems to a broader mathematical and physical context. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Differential geometry" and present it in a talk; • conduct scholarly debates in a familiar context.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Differential geometry"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3313
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4814: Seminar on algebraic topology	2 WLH

	Workload:
Learning outcome, core skills:	Attendance time:
Learning outcome:	28 h
	Self-study time:
In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	62 h

Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students

- know the basic concepts of set-theoretic topology and continuous mappings;
- construct new topologies from given topologies;
- know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;
- apply basic concepts of category theory to topological spaces;
- use concepts of functors to obtain algebraic invariants of topological spaces and mappings;
- know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;
- know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems;
- calculate homology and cohomology with the aid of chain complexes;
- deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;
- become acquainted with connections between analysis and topology;
- apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Algebraic topology" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites:	
Participation in the seminar	

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic topology"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3314
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4815: Seminar on mathematical methods in physics	2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h
In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.	Self-study time: 62 h
The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are	
• harmonic analysis, algebraic structures and representation theory, (group) effects; • operator algebra, C* algebra and von-Neumann algebra; • operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions; • (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.	
One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves.	
Core skills:	
After having successfully completed the module, students will be able to	
• become acquainted with a mathematical topic in the area "Mathematical methods of physics" and present it in a talk; • conduct scholarly debates in a familiar context.	

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Mathematical methods in physics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3315
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]

Number of repeat examinations permitted:	Recommended semester:
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4821: Seminar on algebraic geometry**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students

• are familiar with commutative algebra, also in greater detail;
• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
• examine important examples like elliptic curves, Abelian varieties or algebraic groups;
• use divisors for classification questions;
• study algebraic curves;
• prove the Riemann-Roch theorem and apply it;
• use cohomological concepts and know the basics of Hodge theory;
• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
• get to know connections to complex analysis and to complex geometry.

Core skills:

After having successfully completed the module, students will be able to

• become acquainted with a mathematical topic in the area "Algebraic geometry" and present it in a talk;
• conduct scholarly debates in a familiar context. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements:	

Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic geometry"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3321
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4822: Seminar on algebraic number theory	2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students • know Noetherian and Dedekind rings and the class groups; • are familiar with discriminants, differents and bifurcation theory of Hilbert; • know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL); • are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues; • know densities, the Tchebotarew theorem and applications; • work with orders, S-integers and S-units; • know the class field theory of Hilbert, Takagi and Idele theoretical field theory; • are familiar with Zp-extensions and their Iwasawa theory; • discuss the most important hypotheses of Iwasawa theory and their consequences. Concerning algorithmic aspects of number theory, the following competencies are pursued. Students • work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors; • are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests; • use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics; • discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields; • calculate class groups and fundamental units; • calculate Galois groups of absolute number fields. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Variational analysis" and present it in a talk; • conduct scholarly debates in a familiar context.	Attendance time: 28 h Self-study time: 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic number theory"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3322
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4823: Seminar on algebraic structures**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students

• know basic concepts like rings, modules, algebras and Lie algebras;
• know important examples of Lie algebras and algebras;
• know special classes of Lie groups and their special characteristics;
• know classification theorems for finite-dimensional algebras;
• apply basic concepts of category theory to algebras and modules;
• know group actions and their basic classifications;
• apply the enveloping algebra of Lie algebras;
• apply ring and module theory to basic constructs of algebraic geometry;
• use combinatorial tools for the study of associative algebras and Lie algebras;
• acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups;
• know Hopf algebras as well as their deformation and representation theory.

Core skills:

After having successfully completed the module, students will be able to

• become acquainted with a mathematical topic in the area "Algebraic structures" and present it in a talk;
• conduct scholarly debates in a familiar context. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements:	

Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic structures"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3323
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4824: Seminar on groups, geometry and dynamical systems**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	28 h
In the modules of the cycle "Groups, geometry and dynamical systems" students get to	Self-study time:
know the most important classes of groups as well as the algebraic, geometrical and	62 h
analytical tools that are necessary for their study and applications. They are introduced	
to current research questions and enabled to carry out independent contributions to	
research, e. g. within the scope of a Master's thesis.	
Group theory uses concepts and tools of algebra, geometry and analysis and can be	
applied to these areas. In the course offer several aspects are considered at a time	
and a cycle will only cover some of the learning objectives mentioned below. The	
introduction to the cycle and the specialisation in the cycle will normally cover different	
aspects of the area "Groups, geometry and dynamical systems" that supplement one	
another complementarily. The following content-related competencies are pursued.	
Students	
• know basic concepts of groups and group homomorphisms;	
• know important examples of groups;	
• know special classes of groups and their special characteristics;	
• apply basic concepts of category theory to groups and define spaces via universal	
properties;	
• apply the concepts of functors to obtain algebraic invariants;	
• know group actions and their basic classification results;	
• know the basics of group cohomology and compute these for important examples;	
• know the basics of geometrical group theory like growth characteristics;	
• know self-similar groups, their basic constructs as well as examples with	
interesting characteristics;	
• use geometrical and combinatorial tools for the study of groups;	
• know the basics of the representation theory of compact Lie groups.	
Core skills:	
After having successfully completed the module, students will be able to	
• become acquainted with a mathematical topic in the area "Groups, geometry and	
dynamical systems" and present it in a talk;	
• conduct scholarly debates in a familiar context.	

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements:	

Autonomous permeation and presentation of complex mathematical issues in the area "Groups, geometry and dynamical systems"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3324
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4825: Seminar on non-commutative geometry**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	28 h
In the modules of the cycle "Non-commutative geometry" students get to know the	Self-study time:
conception of space of non-commutative geometry and some of its applications in	62 h
geometry, topology, mathematical physics, the theory of dynamical systems and number	
theory. They are introduced to current research questions and enabled to carry out	
independent contributions to research, e. g. within the scope of a Master's thesis.	

Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued.

Students

- are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;
- construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;
- know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it;
- know important examples of simple C*-algebras and deduce their basic characteristics;
- apply basic concepts of category theory to C*-algebras;
- model the symmetries of non-commutative spaces;
- apply Hilbert modules in C*-algebras;
- know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it;
- apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;
- compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;
- classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;
- classify W*-algebras and know the intrinsic dynamic of factors;
- apply von Neumann algebras to the axiomatic formulation of quantum field theory;
- use von Neumann algebras for the construction of L2 invariants for manifolds and groups;
- understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups;

- define the invariants of algebras and modules with chain complexes and their homology and calculate these;
- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Non-commutative geometry" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Non-commutative geometry"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3325
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4831: Seminar on inverse problems**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems; • evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors; • analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators; • analyse the convergence of regularisation methods with the help of complex analysis; • analyse regularisation methods from stochastic error models; • apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems; • model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region; • analyse the uniqueness and conditional stability of inverse problems of partial differential equations; • deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods; • formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Inverse problems" and present it in a talk; • conduct scholarly debates in a familiar context.	**Attendance time:** 28 h **Self-study time:** 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:**	3 C

Participation in the seminar

Examination requirements:

Autonomous permeation and presentation of complex mathematical issues in the area "Inverse problems"

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3331
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
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.4832: Seminar on approximation methods**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces; • can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces; • know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions; • acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data; • are informed about current developments of efficient data approximation and data analysis; • adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Approximation methods" and present it in a talk; • conduct scholarly debates in a familiar context.	**Attendance time:** 28 h **Self-study time:** 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:**	3 C

Participation in the seminar	

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues in the area "Approximation methods"	

Admission requirements:	**Recommended previous knowledge:**
none	B.Mat.3332
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

| Georg-August-Universität Göttingen | 3 C |
| Module M.Mat.4833: Seminar on numerical methods of partial differential equations | 2 WLH |

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h
The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 62 h

- are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution;
- know the basics of the theory of linear integral equations;
- are familiar with basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM);
- analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;
- apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;
- know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;
- apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems;
- apply available software for the solution of partial differential equations and evaluate the results sceptically;
- evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations;
- know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Numerics of partial differential equations" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: **Seminar** (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Numerical methods of partial differential equations"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3333
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4834: Seminar on optimisation**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • identify optimisation problems in application-oriented problems and formulate these as mathematical programmes; • evaluate the existence and uniqueness of the solution of an optimisation problem; • identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set; • know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised; • analyse the complexity of an optimisation problem; • classify a mathematical programme in a class of optimisation problems and know current solution strategies for it; • develop optimisation methods and adapt general methods to special problems; • deduce upper and lower bounds for optimisation problems and understand their meaning; • understand the geometrical structure of an optimisation problem and apply it for solution strategies; • distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times; • acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation; • acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning; • handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Optimisation" and present it in a talk; • conduct scholarly debates in a familiar context.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Optimisation"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3334
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4837: Seminar on variational analysis**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in variational analysis and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	**Workload:** Attendance time: 28 h Self-study time: 62 h

- understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;
- master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems;
- understand basic concepts of the convergence of sets and continuity of set-valued functions;
- understand basic concepts of variational geometry;
- calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;
- understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;
- analyse constrained and parametric optimisation problems with the help of duality theory;
- calculate and use the Legendre-Fenchel transformation and infimal convulutions;
- formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;
- apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;
- understand the connection between convex functions and monotone operators;
- examine the convergence of fixed point iterations with the help of the theory of monotone operators;
- deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;
- apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;
- model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;
- know applications of control theory and apply methods of dynamic programming;
- use tools of variational analysis in image processing and with inverse problems;
- know basic concepts and methods of stochastic optimisation.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Variational analysis" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Variational analysis"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3337
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4838: Seminar on image and geometry processing	2 WLH

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

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;
- learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;
- learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;
- learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;
- acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;
- know basic concepts and methods of topology;
- are familiar with visualisation software;
- apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
- know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;
- evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;
- are informed about current developments of efficient geometrical and topological data analysis;
- adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Image and geometry processing" and present it in a talk;
- conduct scholarly debates in a familiar context.

Workload:

Attendance time:
28 h
Self-study time:
62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Image and geometry processing"	

Admission requirements: none	Recommended previous knowledge: B.Mat.3338
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4839: Seminar on scientific computing / applied mathematics**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Scientific computing / Applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / Applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions; • know basic methods for the numerical solution of these models; • analyse stability, convergence and efficiency of numerical solution strategies; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware; • use methods of scientific computing for solving application problems, like e. g. of natural and business sciences. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Scientific computing / applied mathematics" and present it in a talk; • conduct scholarly debates in a familiar context.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Scientific computing / applied mathematics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3339
Language:	**Person responsible for module:**

English	Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4841: Seminar on applied and mathematical stochastics	2 WLH

Learning outcome, core skills:	Workload:
Learning outcome:	Attendance time: 28 h
The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students	Self-study time: 62 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students

- are familiar with advanced concepts of probability theory established on measure theory and apply them independently;
- are familiar with substantial concepts and approaches of probability modelling and inferential statistics;
- know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;
- have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;
- understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;
- analyse the convergence characteristic of stochastic processes;
- analyse regularity characteristics of the paths of stochastic processes;
- adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;
- analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed;
- discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Applied and mathematical stochastics" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: **Seminar** (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites: Participation in the seminar	

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues in the area "Applied and mathematical stochastics"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3341

Language:	Person responsible for module:
English	Programme coordinator

Course frequency:	Duration:
not specified	1 semester[s]

Number of repeat examinations permitted:	Recommended semester:
twice	Master: 1 - 4

Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4842: Seminar on stochastic processes**	3 C 2 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with advanced concepts of probability theory established on measure theory and apply them independently; • know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces; • understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes; • know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes; • analyse regularity characteristics of the paths of stochastic processes; • construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics; • are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms; • analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems; • formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics; • are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes; • know fundamental convergence theorems for stochastic processes and generalise these; • model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes; • analyse models in mathematical economics and finance and understand evaluation methods for financial products. **Core skills:** After having successfully completed the module, students will be able to	**Workload:** Attendance time: 28 h Self-study time: 62 h

- become acquainted with a mathematical topic in the area "Variational analysis" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Stochastic processes"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3342
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4843: Seminar on stochastic methods of economathematics**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master problems, basic concepts and stochastic methods of economathematics; • understand stochastic connections; • understand references to other mathematical areas; • get to know possible applications in theory and practice; • gain insight into the connection of mathematics and economic sciences. **Core skills:** After having successfully completed the module, students will be able to • become acquainted with a mathematical topic in the area "Stochastic methods of economathematics" and present it in a talk; • conduct scholarly debates in a familiar context.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Stochastic methods of economathematics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3343
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations:

Instructor: Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen	3 C
Module M.Mat.4844: Seminar on mathematical statistics	2 WLH

	Workload:
Learning outcome, core skills:	Attendance time:
Learning outcome:	28 h
	Self-study time:
The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	62 h

- are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics;
- evaluate statistical methods mathematically precisely via suitable risk and loss concepts;
- analyse optimality characteristics of statistical estimate methods via lower and upper bounds;
- analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;
- are familiar with basic statistical distribution models that base on the theory of exponential indexed families;
- know different techniques to obtain lower and upper risk bounds in these models;
- are confident in modelling typical data structures of regression;
- analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand;
- are able to mathematically analyse resampling methods and apply them purposively;
- are familiar with advanced tools of non-parametric statistics and empirical process theory;
- independently become acquainted with a current topic of mathematical statistics;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Mathematical statistics" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites:	

Participation in the seminar	

Examination requirements: Autonomous permeation and presentation of complex mathematical issues in the area "Mathematical statistics"	

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3344
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4845: Seminar on statistical modelling and inference	2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h
The successful completion of modules of the cycle "Statistical modelling and inference" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	Self-study time: 62 h

- are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation;
- are familiar with the tools of asymptotic statistical inference;
- learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;
- are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;
- become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;
- are able to develop and mathematically evaluate complex statistical models for real data problems.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Statistical modelling and inference" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites: Participation in the seminar	

Examination requirements:
Autonomous permeation and presentation of complex mathematical issues in the area "Statistical modelling and inference"

Admission requirements: none	**Recommended previous knowledge:** B.Mat.3345
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:**

not specified	1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	
Additional notes and regulations: **Instructor:** Lecturers at the Institute of Mathematical Stochastics	

Georg-August-Universität Göttingen **Module M.Mat.4846: Seminar on multivariate statistics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h Self-study time: 62 h
The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	

- are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications;
- can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;
- are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;
- are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;
- are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;
- analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;
- are confident to apply resampling methods to non-Euclidean descriptors;
- are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;
- have a fundamental knowledge of statistics of point processes and Bayesian methods involved;
- are familiar with concepts of large scale computational statistical techniques;
- independently become acquainted with a current topic of multivariate and non-Euclidean statistics;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Multivariate statistics" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C

Examination prerequisites:

Participation in the seminar

Examination requirements:

Autonomous permeation and presentation of complex mathematical issues in the
area "Multivariate statistics"

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3346
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Mat.4847: Seminar on statistical foundations of data science**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	**Workload:** Attendance time: 28 h Self-study time: 62 h

- are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications;
- evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;
- analyse characteristics of statistical estimation methods via lower and upper information bounds;
- are familiar with basic statistical distribution models that base on the theory of exponential families;
- are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies
- analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand;
- are able to mathematically analyse resampling methods and apply them purposively;
- are familiar with concepts of large scale computational statistical techniques;
- are familiar with advanced tools of non-parametric statistics and empirical process theory;
- independently become acquainted with a current topic of statistical data science;
- evaluate complex statistical methods and enhance them in a problem-oriented way.

Core skills:

After having successfully completed the module, students will be able to

- become acquainted with a mathematical topic in the area "Statistical foundations of data science" and present it in a talk;
- conduct scholarly debates in a familiar context.

Course: Seminar (Seminar)	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites:	
Participation in the seminar	

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues in the area "Statistical foundations of data science"	

Admission requirements:	Recommended previous knowledge:
none	B.Mat.3347
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4911: Advanced seminar on analytic number theory**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Analytic number theory" enables students to learn methods, concepts, theories and applications in the area of "Analytic number theory". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;
• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;
• are familiar with results and methods of prime number theory;
• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;
• know basic sieving methods and apply them to the problems of number theory;
• know techniques used to estimate the sum of the sum of characters and of exponentials;
• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;
• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.

Core skills:

After having successfully completed the module, students will be able to

• present a mathematical topic of current research interest in the area "Analytic number theory" in a talk;
• conduct scholarly debates with reference to current research. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Analytic number theory"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4511
Language:	**Person responsible for module:**

English	Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4912: Advanced seminar on analysis of partial differential equations**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Analysis of partial differential equations" enables students to learn methods, concepts, theories and applications in the area "Analysis of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the most important types of partial differential equations and know their solutions; • master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations; • are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations; • apply the basic principles of functional analysis to the solution of partial different equations; • use different theorems of function theory for solving partial different equations; • master different asymptotic techniques to study characteristics of the solutions of partial different equations; • are paradigmatically familiar with broader application areas of linear theory of partial different equations; • are paradigmatically familiar with broader application areas of non-linear theory of partial different equations; • know the importance of partial different equations in the modelling in natural and engineering sciences; • master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Analysis of partial differential equations" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Analysis of partial differential equations"	

Admission requirements:	**Recommended previous knowledge:**
none	M.Mat.4512
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4913: Advanced seminar on differential geometry**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Differential geometry" enables students to learn methods, concepts, theories and applications in the area "Differential geometry". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master the basic concepts of differential geometry; • develop a spatial sense using the examples of curves, surfaces and hypersurfaces; • develop an understanding of the basic concepts of differential geometry like "space" and "manifolds", "symmetry" and "Lie group", "local structures" and "curvature", "global structure" and "invariants" as well as "integrability"; • master (variably weighted and sorted depending on the current courses offered) the theory of transformation groups and symmetries as well as the analysis on manifolds, the theory of manifolds with geometric structures, complex differential geometry, gauge field theory and their applications as well as the elliptical differential equations of geometry and gauge field theory; • develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods; • acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems; • are able to import geometrical problems to a broader mathematical and physical context. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Differential geometry" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Differential geometry"	

Admission requirements:	**Recommended previous knowledge:**
none	M.Mat.4513
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4914: Advanced seminar on algebraic topology**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic topology" students get to know the most important classes of topological spaces as well as algebraic and analytical tools for studying these spaces and the mappings between them. The students use these tools in geometry, mathematical physics, algebra and group theory. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic topology uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic topology and supplement one another complementarily. The following content-related competencies are pursued. Students

• know the basic concepts of set-theoretic topology and continuous mappings;
• construct new topologies from given topologies;
• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;
• apply basic concepts of category theory to topological spaces;
• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;
• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;
• know homology and cohomology, calculate those for important examples and with the aid of these deduce non-existence of mappings as well as fixed-point theorems;
• calculate homology and cohomology with the aid of chain complexes;
• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;
• become acquainted with connections between analysis and topology;
• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.

Core skills:

After having successfully completed the module, students will be able to

• present a mathematical topic of current research interest in the area "Algebraic topology" in a talk;
• conduct scholarly debates with reference to current research. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

| **Course: Advanced seminar** | 2 WLH |

Examination: Oral Presentation (approx. 75 minutes) Examination prerequisites: Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic topology"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4514
Language: English	Person responsible for module: Programme coordinator
Course frequency: not specified	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4915: Advanced seminar on mathematical methods in physics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: In the modules of the cycle "Mathematical methods of physics" students get to know different mathematical methods and techniques that play a role in modern physics. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. The topics of the cycle can be divided into four blocks, a cycle normally contains parts of different blocks, that topically supplement each other, but can also be read within one block. The introducing parts of the cycle form the basis for the advanced specialisation area. The topic blocks are • harmonic analysis, algebraic structures and representation theory, (group) effects; • operator algebra, C* algebra and von-Neumann algebra; • operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions; • (semi) Riemannian geometry, symplectic and Poisson geometry, quantization. One of the aims is that a connection to physical problems is visible, at least in the motivation of the covered topics. Preferably, in the advanced part of the cycle, the students should know and be able to carry out practical applications themselves. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Mathematical methods of physics" in a talk; • conduct scholarly debates with reference to current research.	Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Mathematical methods in physics"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4515
Language: English	**Person responsible for module:** Programme coordinator
Course frequency:	**Duration:**

not specified	1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	
Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute	

Georg-August-Universität Göttingen **Module M.Mat.4921: Advanced seminar on algebraic geometry**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic geometry" students get to know the most important classes of algebraic varieties and schemes as well as the tools for studying these objects and the mappings between them. The students apply these skills to problems of arithmetic or complex analysis. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic geometry uses and connects concepts of algebra and geometry and can be used versatilely. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic geometry and supplement one another complementarily. The following content-related competencies are pursued. Students

• are familiar with commutative algebra, also in greater detail;
• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;
• examine important examples like elliptic curves, Abelian varieties or algebraic groups;
• use divisors for classification questions;
• study algebraic curves;
• prove the Riemann-Roch theorem and apply it;
• use cohomological concepts and know the basics of Hodge theory;
• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;
• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;
• get to know connections to complex analysis and to complex geometry.

Core skills:

After having successfully completed the module, students will be able to

• present a mathematical topic of current research interest in the area "Algebraic geometry" in a talk;
• conduct scholarly debates with reference to current research. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements:	

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic geometry"

Admission requirements:	Recommended previous knowledge:
none	M.Mat.4521
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4922: Advanced seminar on algebraic number theory**	3 C 2 WLH
Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Algebraic number theory" enables students to learn methods, concepts, theories and applications in the areas "Algebraic number theory" and "Algorithmic number theory". During the course of the cycle students will be successively introduced to current theoretical and/or applied research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued in relation to algebra. Students • know Noetherian and Dedekind rings and the class groups; • are familiar with discriminants, differents and bifurcation theory of Hilbert; • know geometrical number theory with applications to the unit theorem and the finiteness of class groups as well as the algorithmic aspects of lattice theory (LLL); • are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues; • know densities, the Tchebotarew theorem and applications; • work with orders, S-integers and S-units; • know the class field theory of Hilbert, Takagi and Idele theoretical field theory; • are familiar with Zp-extensions and their Iwasawa theory; • discuss the most important hypotheses of Iwasawa theory and their consequences. Concerning algorithmic aspects of number theory, the following competencies are pursued. Students • work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors; • are familiar with basic algorithms of number theory in long arithmetic like GCD, fast number and polynomial arithmetic, interpolation and evaluation and prime number tests; • use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics; • discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields; • calculate class groups and fundamental units; • calculate Galois groups of absolute number fields. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Algebraic number theory" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) Examination prerequisites: Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic number theory"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4522
Language: English	Person responsible for module: Programme coordinator
Course frequency: not specified	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4923: Advanced seminar on algebraic structures**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

In the modules of the cycle "Algebraic structures" students get to know different algebraic structures, amongst others Lie algebras, Lie groups, analytical groups, associative algebras as well as the tools from algebra, geometry and category theory that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis.

Algebraic structures use concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of algebraic structures and supplement one another complementarily. The following content-related competencies are pursued. Students

• know basic concepts like rings, modules, algebras and Lie algebras;
• know important examples of Lie algebras and algebras;
• know special classes of Lie groups and their special characteristics;
• know classification theorems for finite-dimensional algebras;
• apply basic concepts of category theory to algebras and modules;
• know group actions and their basic classifications;
• apply the enveloping algebra of Lie algebras;
• apply ring and module theory to basic constructs of algebraic geometry;
• use combinatorial tools for the study of associative algebras and Lie algebras;
• acquire solid knowledge of the representation theory of Lie algebras, finite groups and compact Lie groups as well as the representation theory of semisimple Lie groups;
• know Hopf algebras as well as their deformation and representation theory.

Core skills:
After having successfully completed the module, students will be able to

• present a mathematical topic of current research interest in the area "Algebraic structures" in a talk;
• conduct scholarly debates with reference to current research. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements:	

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic structures"

Admission requirements:	**Recommended previous knowledge:**
none	M.Mat.4523
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4924: Advanced seminar on groups, geometry and dynamical systems**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** In the modules of the cycle "Groups, geometry and dynamical systems" students get to know the most important classes of groups as well as the algebraic, geometrical and analytical tools that are necessary for their study and applications. They are introduced to current research questions and enabled to carry out independent contributions to research, e. g. within the scope of a Master's thesis. Group theory uses concepts and tools of algebra, geometry and analysis and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of the area "Groups, geometry and dynamical systems" that supplement one another complementarily. The following content-related competencies are pursued. Students • know basic concepts of groups and group homomorphisms; • know important examples of groups; • know special classes of groups and their special characteristics; • apply basic concepts of category theory to groups and define spaces via universal properties; • apply the concepts of functors to obtain algebraic invariants; • know group actions and their basic classification results; • know the basics of group cohomology and compute these for important examples; • know the basics of geometrical group theory like growth characteristics; • know self-similar groups, their basic constructs as well as examples with interesting characteristics; • use geometrical and combinatorial tools for the study of groups; • know the basics of the representation theory of compact Lie groups. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Groups, geometry and dynamical systems" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements:	

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Groups, geometry and dynamical systems"

Admission requirements:	**Recommended previous knowledge:**
none	M.Mat.4524
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen	3 C
	2 WLH
Module M.Mat.4925: Advanced seminar on non-commutative geometry	

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
	28 h
In the modules of the cycle "Non-commutative geometry" students get to know the	Self-study time:
conception of space of non-commutative geometry and some of its applications in	62 h
geometry, topology, mathematical physics, the theory of dynamical systems and number	
theory. They are introduced to current research questions and enabled to carry out	
independent contributions to research, e. g. within the scope of a Master's thesis.	

Non-commutative geometry uses concepts of analysis, algebra, geometry and mathematical physics and can be applied to these areas. In the course offer several aspects are considered at a time and a cycle will only cover some of the learning objectives mentioned below. The introduction to the cycle and the specialisation in the cycle will normally cover different aspects of non-commutative geometry that supplement one another complementarily. The following content-related competencies are pursued. Students

- are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;
- construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;
- know the spectral theory of commutative C*-algebras and analyse normal operators in Hilbert spaces with it;
- know important examples of simple C*-algebras and deduce their basic characteristics;
- apply basic concepts of category theory to C*-algebras;
- model the symmetries of non-commutative spaces;
- apply Hilbert modules in C*-algebras;
- know the definition of the K-theory of C*-algebras and their formal characteristics and calculate the K-theory of C*-algebras for important examples with it;
- apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;
- compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;
- classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;
- classify W*-algebras and know the intrinsic dynamic of factors;
- apply von Neumann algebras to the axiomatic formulation of quantum field theory;
- use von Neumann algebras for the construction of L2 invariants for manifolds and groups;
- understand the connection between the analysis of C*- and W*-algebras of groups and geometrical characteristics of groups;
- define the invariants of algebras and modules with chain complexes and their homology and calculate these;

- interpret these homological invariants geometrically and correlate them with each other;
- abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.

Core skills:

After having successfully completed the module, students will be able to

- present a mathematical topic of current research interest in the area "Non-commutative geometry" in a talk;
- conduct scholarly debates with reference to current research.

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Non-commutative geometry"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4525
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations: **Instructor:** Lecturers at the Mathematical Institute

Georg-August-Universität Göttingen **Module M.Mat.4931: Advanced seminar on inverse problems**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Inverse problems" enables students to learn methods, concepts, theories and applications in the area of "Inverse problems". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;
• evaluate different regularisation methods for ill posed inverse problems under algorithmic aspects and with regard to various a priori information and distinguish concepts of convergence for such methods with deterministic and stochastic data errors;
• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;
• analyse the convergence of regularisation methods with the help of complex analysis;
• analyse regularisation methods from stochastic error models;
• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;
• model identification problems in natural sciences and technology as inverse problems of partial differential equations where the unknown is e. g. a coefficient, an initial or a boundary condition or the shape of a region;
• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;
• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;
• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.

Core skills:

After having successfully completed the module, students will be able to

• present a mathematical topic of current research interest in the area "Inverse problems" in a talk;
• conduct scholarly debates with reference to current research. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:**	3 C

Participation in the advanced seminar	

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Inverse problems"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4531
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4932: Advanced seminar on approximation methods**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Approximation methods" enables students to learn methods, concepts, theories and applications in the area of "Approximation methods", so the approximation of one- and multidimensional functions as well as for the analysis and approximation of discrete signals and images. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	28 h Self-study time: 62 h

- are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;
- can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;
- know and use parts of classical approximation theory, e. g. Jackson and Bernstein theorems for the approximation quality for trigonometrical polynomials, approximation in translationally invariant spaces; polynomial reductions and Strang-Fix conditions;
- acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;
- apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;
- evaluate different numerical methods for the efficient solution of the approximation problems on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;
- are informed about current developments of efficient data approximation and data analysis;
- adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.

Core skills:

After having successfully completed the module, students will be able to

- present a mathematical topic of current research interest in the area "Approximation methods" in a talk;
- conduct scholarly debates with reference to current research.

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:**	3 C

Participation in the advanced seminar	

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Approximation methods"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4532
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4933: Advanced seminar on numerical methods of partial differential equations**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Numerics of partial differential equations" enables students to learn methods, concepts, theories and applications in the area of "Numerics of partial differential equations". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students	28 h Self-study time: 62 h

- are familiar with the theory of linear partial differential equations, e. g. questions of classification as well as existence, uniqueness and regularity of the solution;
- know the basics of the theory of linear integral equations;
- are familiar with basic methods for the numerical solution of linear partial differential equations with finite difference methods (FDM), finite element methods (FEM) as well as boundary element methods (BEM);
- analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;
- apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;
- know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;
- apply methods for the solution of larger systems of linear and stiff ordinary differential equations and are familiar with the problem of differential algebraic problems;
- apply available software for the solution of partial differential equations and evaluate the results sceptically;
- evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;
- acquire advanced knowledge in the theory as well as development and application of numerical solution strategies in a special area of partial differential equations, e. g. in variation problems with constraints, singularly perturbed problems or of integral equations;
- know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.

Core skills:

After having successfully completed the module, students will be able to

- present a mathematical topic of current research interest in the area "Numerics of partial differential equations" in a talk;
- conduct scholarly debates with reference to current research.

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) Examination prerequisites: Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Numerical methods of partial differential equations"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4533
Language: English	Person responsible for module: Programme coordinator
Course frequency: not specified	Duration: 1 semester[s]
Number of repeat examinations permitted: twice	Recommended semester: Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	3 C
Module M.Mat.4934: Advanced seminar on optimisation	2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time: 28 h
	Self-study time: 62 h

Learning outcome, core skills:

Learning outcome:

The successful completion of modules of the cycle "Optimisation" enables students to learn methods, concepts, theories and applications in the area of "Optimisation", so the discrete and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

- identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;
- evaluate the existence and uniqueness of the solution of an optimisation problem;
- identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;
- know which special characteristics of the target function and the constraints (like (virtual) convexity, dc functions) for the development of solution strategies can be utilised;
- analyse the complexity of an optimisation problem;
- classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;
- develop optimisation methods and adapt general methods to special problems;
- deduce upper and lower bounds for optimisation problems and understand their meaning;
- understand the geometrical structure of an optimisation problem and apply it for solution strategies;
- distinguish between proper solution methods, approximation methods with quality guarantee and heuristics and evaluate different methods on the basis of the quality of the found solutions and their computing times;
- acquire advanced knowledge in the development of solution strategies on the basis of a special area of optimisation, e. g. integer optimisation, optimisation of networks or convex optimisation;
- acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;
- handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.

Core skills:

After having successfully completed the module, students will be able to

- present a mathematical topic of current research interest in the area "Optimisation" in a talk;
- conduct scholarly debates with reference to current research.

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Optimisation"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4534
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4937: Advanced seminar on variational analysis**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Variational analysis" enables students to learn methods, concepts, theories and applications in variational analysis and continuous optimisation. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems; • master the characteristics of convexity and other concepts of the regularity of sets and functions to evaluate the existence and regularity of the solutions of variational problems; • understand basic concepts of the convergence of sets and continuity of set-valued functions; • understand basic concepts of variational geometry; • calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions; • understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals; • analyse constrained and parametric optimisation problems with the help of duality theory; • calculate and use the Legendre-Fenchel transformation and infimal convulutions; • formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis; • apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria; • understand the connection between convex functions and monotone operators; • examine the convergence of fixed point iterations with the help of the theory of monotone operators; • deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence; • apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems; • model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations; • know applications of control theory and apply methods of dynamic programming; • use tools of variational analysis in image processing and with inverse problems; • know basic concepts and methods of stochastic optimisation. **Core skills:**	**Workload:** Attendance time: 28 h Self-study time: 62 h

After having successfully completed the module, students will be able to

- present a mathematical topic of current research interest in the area "Variational analysis" in a talk;
- conduct scholarly debates with reference to current research.

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Variational analysis"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4537
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4938: Advanced seminar on image and geometry processing**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Image and geometry processing" enables students to learn and apply methods, concepts, theories and applications in the area of "Image and geometry processing", so the digital image and geometry processing. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces; • learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces; • learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform; • learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces; • acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies; • know basic concepts and methods of topology; • are familiar with visualisation software; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • know which special characteristics of an image or of a geometry can be extracted and worked on with which methods; • evaluate different numerical methods for the efficient analysis of multidimensional data on the basis of the quality of the solutions, the complexity and their computing time; • acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data; • are informed about current developments of efficient geometrical and topological data analysis; • adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Image and geometry processing" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites: Participation in the advanced seminar	

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Image and geometry processing"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4538
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4939: Advanced seminar on scientific computing / applied mathematics**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Scientific computing / applied mathematics" enables students to learn and apply methods, concepts, theories and applications in the area of "Scientific computing / applied mathematics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a practical course in scientific computing or a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions; • know basic methods for the numerical solution of these models; • analyse stability, convergence and efficiency of numerical solution strategies; • apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically; • evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time; • are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware; • use methods of scientific computing for solving application problems, like e. g. of natural and business sciences. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Scientific computing / applied mathematics" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Scientific computing / applied mathematics"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4539
Language:	**Person responsible for module:**

English	Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
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.4941: Advanced seminar on applied and mathematical stochastics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome:	Attendance time:
The successful completion of modules of the cycle "Applied and mathematical stochastics" enables students to understand and apply a broad range of problems, theories, modelling and proof techniques of stochastics. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued: Students	28 h Self-study time: 62 h
• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;	
• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;	
• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;	
• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;	
• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;	
• analyse the convergence characteristic of stochastic processes;	
• analyse regularity characteristics of the paths of stochastic processes;	
• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;	
• analyse probabilistic and statistic models regarding their typical characteristics, estimate unknown parameters and make predictions for their paths on areas not observed / at times not observed;	
• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.	
Core skills:	
After having successfully completed the module, students will be able to	
• present a mathematical topic of current research interest in the area "Applied and mathematical stochastics" in a talk;	
• conduct scholarly debates with reference to current research.	

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements:	
Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Applied and mathematical stochastics"	

Admission requirements:	Recommended previous knowledge:
none	M.Mat.4541

Language:	Person responsible for module:
English	Programme coordinator

Course frequency:	Duration:
not specified	1 semester[s]

Number of repeat examinations permitted:	Recommended semester:
twice	Master: 1 - 4

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.4942: Advanced seminar on stochastic processes**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Stochastic processes" enables students to learn and apply methods, concepts, theories and proof techniques in the area of "Stochastic processes" and use these for the modelling of stochastic systems. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with advanced concepts of probability theory established on measure theory and apply them independently; • know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces; • understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes; • know fundamental classes of stochastic processes (like e. g. Poisson processes, Brownian motions, Levy processes, stationary processes, multivariate and spatial processes as well as branching processes) and construct and characterise these processes; • analyse regularity characteristics of the paths of stochastic processes; • construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics; • are familiar with the theory of general Markov processes and characterise and analyse these with the use of generators, semigroups, martingale problems and Dirichlet forms; • analyse martingales in discrete and continuous time using the corresponding martingale theory, especially using martingale equations, martingale convergence theorems, martingale stopping theorems and martingale representation theorems; • formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics; • are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes; • know fundamental convergence theorems for stochastic processes and generalise these; • model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes; • analyse models in mathematical economics and finance and understand evaluation methods for financial products. **Core skills:** After having successfully completed the module, students will be able to	**Workload:** Attendance time: 28 h Self-study time: 62 h

- present a mathematical topic of current research interest in the area "Stochastic processes" in a talk;
- conduct scholarly debates with reference to current research.

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Stochastic processes"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4542
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4943: Advanced seminar on stochastic methods in economathematics**	3 C 2 WLH

Learning outcome, core skills: **Learning outcome:** The successful completion of modules of the cycle "Stochastic methods of economathematics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • master problems, basic concepts and stochastic methods of economathematics; • understand stochastic connections; • understand references to other mathematical areas; • get to know possible applications in theory and practice; • gain insight into the connection of mathematics and economic sciences. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Stochastic methods in economathematics" in a talk; • conduct scholarly debates with reference to current research.	**Workload:** Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Stochastic methods in economathematics"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4543
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations:

Instructor: Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Mat.4944: Advanced seminar on mathematical statistics**	3 C 2 WLH

| **Learning outcome, core skills:**
Learning outcome:

The successful completion of modules of the cycle "Mathematical statistics" enables students to learn methods, concepts, theories and applications in the area of "Mathematical statistics". During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Bachelor's or Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students

are familiar with the most important methods of mathematical statistics like estimates, testing, confidence propositions and classification and use them in simple models of mathematical statistics;
evaluate statistical methods mathematically precisely via suitable risk and loss concepts;
analyse optimality characteristics of statistical estimate methods via lower and upper bounds;
analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;
are familiar with basic statistical distribution models that base on the theory of exponential indexed families;
know different techniques to obtain lower and upper risk bounds in these models;
are confident in modelling typical data structures of regression;
analyse practical statistical problems in a mathematically accurate way with the techniques learned on the one hand and via computer simulations on the other hand;
are able to mathematically analyse resampling methods and apply them purposively;
are familiar with advanced tools of non-parametric statistics and empirical process theory;
independently become acquainted with a current topic of mathematical statistics;
evaluate complex statistical methods and enhance them in a problem-oriented way.
Core skills:

After having successfully completed the module, students will be able to

present a mathematical topic of current research interest in the area "Mathematical statistics" in a talk; conduct scholarly debates with reference to current research. | **Workload:**
Attendance time:
28 h
Self-study time:
62 h |

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C

Examination prerequisites:

Participation in the advanced seminar

Examination requirements:

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Mathematical statistics"

Admission requirements:	Recommended previous knowledge:
none	M.Mat.4544
Language:	**Person responsible for module:**
English	Programme coordinator
Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

Additional notes and regulations:

Instructor: Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Mat.4945: Advanced seminar on statistical modelling and inference**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Statistical modelling and inference" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are familiar with the fundamental principles of statistics and inference in parametric and non-parametric models: estimation, testing, confidence statements, prediction, model selection and validation; • are familiar with the tools of asymptotic statistical inference; • learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods; • are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties; • become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.; • are able to develop and mathematically evaluate complex statistical models for real data problems. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Statistical modelling and inference" in a talk; • conduct scholarly debates with reference to current research.	Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes) **Examination prerequisites:** Participation in the advanced seminar	3 C

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Statistical modelling and inference"	

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4545
Language: English	**Person responsible for module:** Programme coordinator

Course frequency:	**Duration:**
not specified	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	Master: 1 - 4
Maximum number of students:	
not limited	

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

Georg-August-Universität Göttingen **Module M.Mat.4946: Advanced seminar on multivariate statistics**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Multivariate statistics" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students • are well acquainted with the most important methods of multivariate statistics like estimation, testing, confidence statements, prediction, linear and generalized linear models, and use them in modeling real world applications; • can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling; • are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models; • are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis; • are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae; • analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions; • are confident to apply resampling methods to non-Euclidean descriptors; • are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines; • have a fundamental knowledge of statistics of point processes and Bayesian methods involved; • are familiar with concepts of large scale computational statistical techniques; • independently become acquainted with a current topic of multivariate and non-Euclidean statistics; • evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to • present a mathematical topic of current research interest in the area "Multivariate statistics" in a talk; • conduct scholarly debates with reference to current research.	**Attendance time:** 28 h **Self-study time:** 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C

Examination prerequisites:

Participation in the advanced seminar

Examination requirements:

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Multivariate statistics"

Admission requirements: none	**Recommended previous knowledge:** M.Mat.4546
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

Additional notes and regulations:

Instructor: Lecturers at the Institute of Mathematical Stochastics

Georg-August-Universität Göttingen **Module M.Mat.4947: Advanced seminar on statistical foundations of data science**	3 C 2 WLH

Learning outcome, core skills:	**Workload:**
Learning outcome: The successful completion of modules of the cycle "Statistical foundations of data science" enables students to learn methods, concepts, theories and applications in this area. During the course of the cycle students will be successively introduced to current research topics and able to carry out independent contributions to research (e. g. within the scope of a Master's thesis). Depending on the current course offer the following content-related competencies may be pursued. Students - are familiar with the most important methods of statistical foundations of data science like estimation, testing, confidence statements, prediction, resampling, pattern recognition and classification, and use them in modeling real world applications; - evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts; - analyse characteristics of statistical estimation methods via lower and upper information bounds; - are familiar with basic statistical distribution models that base on the theory of exponential families; - are confident in modelling real world data structures such as categorial data, multidimensional and high dimensional data, data in imaging, data with serial dependencies - analyse practical statistical problems in a mathematically accurate way with the techniques and models learned on the one hand and via computer simulations on the other hand; - are able to mathematically analyse resampling methods and apply them purposively; - are familiar with concepts of large scale computational statistical techniques; - are familiar with advanced tools of non-parametric statistics and empirical process theory; - independently become acquainted with a current topic of statistical data science; - evaluate complex statistical methods and enhance them in a problem-oriented way. **Core skills:** After having successfully completed the module, students will be able to - present a mathematical topic of current research interest in the area "Statistical foundations of data science" in a talk; - conduct scholarly debates with reference to current research.	Attendance time: 28 h Self-study time: 62 h

Course: Advanced seminar	2 WLH

Examination: Oral Presentation (approx. 75 minutes)	3 C
Examination prerequisites: Participation in the advanced seminar	

Examination requirements: Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Statistical foundations of data science"	

Admission requirements: none	Recommended previous knowledge: M.Mat.4547
Language: English	**Person responsible for module:** Programme coordinator
Course frequency: not specified	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** Master: 1 - 4
Maximum number of students: not limited	

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

Georg-August-Universität Göttingen	9 C
Modul M.Phi.101: Ausgewählte Themen der Theoretischen Philosophie	4 SWS
English title: Selected Topics in Theoretical Philosophy	

Lernziele/Kompetenzen:	Arbeitsaufwand:
Das Wahlpflichtmodul dient der Erweiterung der Kenntnisse und Fähigkeiten in einem Wahlbereich der Philosophie. Im 42-C-Master-Fach wird hier ein Schwerpunkt mit vertieften Kenntnissen ausgebildet. Im 78-C-Master-Fach sollen ergänzende Themen studiert werden, die nicht im Bereich des zu wählenden Studienschwerpunktes (s. Module 104-107) liegen.	Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden
Die Studierenden besitzen vermehrte Kenntnis von Theorieansätzen und umfassendere Problemperspektiven auf Gebieten der Theoretischen Philosophie. Sie kennen unterschiedliche Methoden und Terminologien, können Positionen und Problemstellungen in größere Zusammenhänge einordnen, mit anderen Positionen vergleichen und ihre Relevanz und Leistungsfähigkeit beurteilen. Z.B. können erkenntnistheoretische Ansätze durch zusätzliche Kenntnisse aus der Sprachphilosophie, der Ontologie oder der Philosophie des Geistes adäquater eingeschätzt werden und umgekehrt.	

Lehrveranstaltungen:	
1. Eine Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der theoretischen Philosophie	2 SWS
2. Ein Seminar oder Hauptseminar zu einem Thema der theoretischen Philosophie	2 SWS
Prüfung: Hausarbeit (max. 15 Seiten) oder mündliche Prüfung (ca. 30 Minuten) Prüfungsvorleistungen: Eine kleine schriftliche Leistung pro Veranstaltung (max. 3 Seiten)	9 C

Prüfungsanforderungen:	
Kenntnisse wichtiger Positionen der Sprachphilosophie, Erkenntnistheorie, Philosophie des Geistes, Wissenschaftsphilosophie oder Metaphysik; Fähigkeit, philosophische Probleme in diesen Bereichen zu behandeln und Lösungsvorschläge unter sachgerechter Abwägung von Argumenten zu diskutieren.	

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Christian Beyer
Angebotshäufigkeit: jedes Semester	**Dauer:** 1-2 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 3
Maximale Studierendenzahl: 25	

Georg-August-Universität Göttingen **Modul M.Phi.102: Ausgewählte Themen der Praktischen Philosophie** *English title: Selected Topics in Practical Philosophy*	9 C 4 SWS

Lernziele/Kompetenzen:	Arbeitsaufwand:
Das Wahlpflichtmodul dient der Erweiterung der Kenntnisse und Fähigkeiten in einem Wahlbereich der Philosophie. Im 42-C-Master-Fach wird hier ein Schwerpunkt mit vertieften Kenntnissen ausgebildet. Im 78-C-Master-Fach sollen ergänzende Themen studiert werden, die nicht im Bereich des zu wählenden Studienschwerpunktes (s. Module 104-107) liegen. Die Studierenden besitzen erweiterte Kenntnisse von Theorieansätzen in mehreren Bereichen der Praktischen Philosophie. Sie können ethische und politiktheoretische Positionen und Problemstellungen in größere Zusammenhänge einordnen, unterschiedliche Ansätze vergleichen und ihre Relevanz und Leistungsfähigkeit beurteilen. Im Bereich der Ethik wird z.B. die Kenntnis individualethischer Positionen durch solche der Sozialethik oder der politischen Philosophie ergänzt, durch Ansätze der Metaethik in der Grundlagendimension vertieft oder durch Ansätze der Angewandten Ethik in der Anwendungsdimension konkretisiert.	Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden

Lehrveranstaltungen:	
1. Eine Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der praktischen Philosophie	2 SWS
2. Ein Seminar oder Hauptseminar zu einem Thema der praktischen Philosophie	2 SWS
Prüfung: Hausarbeit (max. 15 Seiten) oder mündliche Prüfung (ca. 30 Minuten) **Prüfungsvorleistungen:** Eine kleine schriftliche Leistung pro Veranstaltung (max. 3 Seiten)	9 C

Prüfungsanforderungen:	
Kenntnisse wichtiger Positionen der Theoretischen oder der Angewandten Ethik oder der Politischen Philosophie; Fähigkeit, philosophische Probleme in diesen Bereichen zu behandeln und Lösungsvorschläge unter sachgerechter Abwägung von Argumenten zu diskutieren.	

Zugangsvoraussetzungen: keine	Empfohlene Vorkenntnisse: keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Holmer Steinfath
Angebotshäufigkeit: jedes Semester	**Dauer:** 1-2 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 3
Maximale Studierendenzahl: 25	

Georg-August-Universität Göttingen **Modul M.Phi.103: Ausgewählte Themen der Geschichte der Philosophie** *English title: Selected Topics in History of Philosophy*	9 C 4 SWS

Lernziele/Kompetenzen: Das Wahlpflichtmodul dient der Erweiterung der Kenntnisse und Fähigkeiten in einem Wahlbereich der Philosophie. Im 42-C-Master-Fach wird hier ein Schwerpunktbereich mit vertieften Kenntnissen ausgebildet. Im 78-C-Master-Fach sollen ergänzende Themen studiert werden, die nicht im Bereich des zu wählenden Studienschwerpunktes (s. Module 104-107) liegen. Die Studierenden kennen verschiedene philosophiegeschichtliche Theorieansätze und die wesentlichen Diskussionszusammenhänge, in denen sie stehen. Klassische Primärtexte können unter Einbeziehung ihrer historischen und systematischen Kontexte sachgemäß interpretiert und analysiert werden. Philosophische Positionen können entwicklungsgeschichtlich aufeinander bezogen, fortschrittliche und wiederkehrende Elemente darin erkannt und Diskussionsbeiträge oder Theorieentwürfe nach ihrer theoriegeschichtlichen Bedeutung eingeschätzt werden.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden

Lehrveranstaltungen:	
1. Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der Geschichte der Philosophie	2 SWS
2. Seminar oder Hauptseminar zu einem Thema der Geschichte der Philosophie	2 SWS
Prüfung: Hausarbeit (max. 15 Seiten) oder mündliche Prüfung (ca. 30 Minuten) **Prüfungsvorleistungen:** Eine kleine schriftliche Leistung pro Veranstaltung (max. 3 Seiten)	9 C

Prüfungsanforderungen: Kenntnisse wichtiger philosophiegeschichtlicher Werke und Positionen; Fähigkeit, klassische Texte sachgemäß zu interpretieren, in ihre historischen und systematischen Kontexte einzuordnen und ihre theoretische Leistungsfähigkeit zu beurteilen.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** keine
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Bernd Ludwig
Angebotshäufigkeit: jedes Semester	**Dauer:** 1-2 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 3
Maximale Studierendenzahl: 25	

Georg-August-Universität Göttingen **Modul M.WIWI-BWL.0001: Finanzwirtschaft** *English title: Corporate Finance*	6 C 4 SWS

Lernziele/Kompetenzen: Nach dem erfolgreichen Absolvieren des Moduls sollten die Studierenden in der Lage sein • einen vertieften Überblick über die grundlegenden Fragen der betrieblichen Finanzwirtschaft und ihre Verbindungen zueinander zu geben. • zentrale Methoden der Risikoanalyse und der Beurteilung von Investitionen verstehen, anwenden und kritisch reflektieren können. • zentrale Theorien zur Marktbewertung riskanter Zahlungsströme zu verstehen und diskutieren können. • die Hypothesen zur Informationseffizienz von Kapitalmärkten zu verstehen und deren Konsequenzen für Investoren und Unternehmen zu beurteilen. • verhaltenswissenschaftliche Aspekte in Finanzmärkten, deren ökonomische Fundierung und deren Auswirkungen auf Investitions- und Finanzierungsentscheidungen zu verstehen und kritisch zu diskutieren. • Theorien zur optimalen Kapitalstruktur und Dividendenpolitik von Unternehmen zu verstehen und deren Verbindungen zu verschiedenen Marktfriktionen und Prinzipal-Agenten-Probleme aufzeigen zu können. • Theorien zur optimalen Kapitalstruktur und Dividendenpolitik von Unternehmen hinsichtlich ihrer praktischen Implikationen und ihrer Fähigkeit zur Erklärung empirischer Phänomene beurteilen zu können.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltungen: **1. Finanzwirtschaft** (Vorlesung) *Inhalte*: 1. Grundlegende Fragestellungen der betrieblichen Finanzwirtschaft 2. Investitionsentscheidungen unter Risiko: Risikoanalyse und subjektive Bewertung 3. Investitionsentscheidungen unter Risiko: Marktbewertung - Bewertungsmodelle (Capital Asset Pricing Model, Arbitrage Pricing Theory, Empirische Faktormodelle) 4. Investitionsentscheidungen unter Risiko: Marktbewertung - Implementierung 5. Finanzierungsinstrumente, effiziente Kapitalmärkte, Behavioral Finance und Finanzierungsentscheidungen 6. Kapitalstrukturentscheidungen 7. Dividenden und Ausschüttungspolitik Teile des Materials der Vorlesungen werden durch Aufzeichnungen vermittelt, die von den Studierenden eigenständig durchzuarbeiten sind	2 SWS
2. Finanzwirtschaft (Übung) *Inhalte*: Im Rahmen der begleitenden Übung vertiefen und erweitern die Studierenden die in der Vorlesung erworbenen Kenntnisse und Fähigkeiten	2 SWS
Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen:
- Darlegung eines übergreifenden Verständnisses grundlegender finanzwirtschaftlicher Fragestellungen.
- Nachweis der Kenntnis zentraler Methoden der Risikoanalyse und der Beurteilung von Investitionen unter Risiko sowie der Fähigkeit diese anzuwenden.
- Nachweis des Verständnisses zentraler Theorien zur Marktbewertung riskanter Zahlungsströme und der Fähigkeit zur kritischen Beurteilung dieser Theorien.
- Nachweis des Verständnisses der Hypothesen zur Informations-effizienz von Kapitalmärkten, verhaltenswissenschaftlicher Phänomene auf Kapitalmärkten sowie deren praktischer Implikationen für Investoren und Unternehmen.
- Fähigkeit zur Analyse von Fragen der optimalen Kapitalstruktur und der Dividendenpolitik von Unternehmen vor dem Hintergrund verschiedener Marktfriktionen und Prinzipal-Agenten-Problemen.

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Grundkenntnisse aus finanzwirtschaftlichen Veranstaltungen im Bachelorstudium
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Olaf Korn
Angebotshäufigkeit: jedes Sommersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 2
Maximale Studierendenzahl: nicht begrenzt	

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 should be 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

Courses: **1. Financial Risk Management** (Lecture) *Contents*: 1. Introduction 2. Risk Management: Motivation and Strategies 3. Managing International Risks 4. Managing Interest Rate Risk 5. Managing Credit Risk 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
2. Financial Risk Management (Tutorial) *Contents*: In the accompanying practice sessions students deepen and broaden their knowledge from the lectures.	2 WLH

Examination: Written examination (90 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:	**Recommended previous knowledge:**
none	M.WIWI-BWL.0001 „Finanzwirtschaft"
Language:	**Person responsible for module:**
English	Prof. Dr. Olaf Korn
Course frequency:	**Duration:**
Every winter semester during the first half of the semester	1 semester[s]
Number of repeat examinations permitted:	**Recommended semester:**
twice	2 - 3
Maximum number of students:	
not limited	

Georg-August-Universität Göttingen **Modul M.WIWI-BWL.0008: Derivate** *English title: Derivatives*	6 C 4 SWS

Lernziele/Kompetenzen: Nach dem erfolgreichen Absolvieren des Moduls sollten die Studierenden • vertiefte Kenntnisse über die verschiedenen Formen von Derivaten, insbesondere deren Ausgestaltung, Handel und Bedeutung, besitzen. • verschiedene Bewertungsansätze für Derivate (Duplikationsprinzip, Hedgingprinzip, Risikoneutrale Bewertung) verstehen und interpretieren können. • die der Bewertung von Derivaten zugrundeliegende ökonomische Argumentation verstehen und diese kritisch reflektierend bewerten können. • die für die Bewertung und dem Risikomanagement von Derivaten erforderlichen mathematisch-statistischen Verfahren und Kennzahlten verstehen und anwenden können. • auch komplexe Derivate analysieren und selbständig computergestützt bewerten können.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltungen: **1. Derivate** (Vorlesung) *Inhalte*: 1. Einführung 1.1. Begriffliche Grundlagen 1.2. Grundidee der Derivatebewertung 2. Forwards und Futures 2.1. Arbitragefreie Terminpreise 2.2. Forwards versus Futures 3. Optionen 3.1. Grundlagen 3.2. Verteilungsfreie Wertgrenzen 3.3. Arbitrageorientierte Bewertung 4. Risikomanagement von Derivatepositionen 4.1. Optionssensitivitäten 4.2. Risikosteuerung 4.3. Marktfriktionen und gleichgewichtsorientierte Bewertung	2 SWS

Die Erarbeitung des Vorlesungsstoffes erfolgt z.T. im Selbststudium auf Basis von Vorlesungsaufzeichnungen. In den Präsenzzeiten während der Vorlesungstermine kann daher verstärkt an Fallbeispielen und der konkreten Umsetzung der Konzepte durch die Studierenden gearbeitet werden.	
2. Derivate (Übung) *Inhalte*: Im Rahmen der begleitenden Übung vertiefen und erweitern die Studierenden die in der Vorlesung erworbenen Kenntnisse und Fähigkeiten	2 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: • Nachweis von Kenntnissen über die Ausgestaltungsformen von Derivaten, den Derivatehandel und die Bedeutung unterschiedlicher Produkte. • Nachweis von Kenntnissen über die verschiedenen Bewertungsansätze von Derivaten. • Nachweis über die Fähigkeit zur kritischen Analyse von Bewertungsmodellen und ihrer Annahmen. • Nachweis von Kenntnissen über die sich aus Bewertungsmodellen ergebenen Verfahren zum Risikomanagement von Derivaten und deren Anwendung. • Fähigkeit zur eigenständigen komplexer Derivatepositionen und zur Ermittlung von modellbasierten Werten.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Grundkenntnisse aus finanzwirtschaftlichen Veranstaltungen im Bachelorstudium
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Olaf Korn
Angebotshäufigkeit: jedes Wintersemester in der zweiten Hälfte der Vorlesungszeit	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 3
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen **Modul M.WIWI-BWL.0023: Management Accounting** *English title: Management Accounting*	6 C 3 SWS

Lernziele/Kompetenzen: Studierende sollen die konzeptionellen Grundlagen der wesentlichen Kennzahlen im Bereich der wertorientierten Unternehmensführung kennenlernen. Durch die Kombination von wissenschaftlichen Kenntnissen und praxisnahen Inhalten sollen die Studierenden Kenntnis über die positiven und negativen Wirkungen von Instrumenten des Value Based Managements erlangen. Des Weiteren sollen die Studierenden das Zusammenspiel und die Eignung der Implementierung von Elementen des Value Based Management und im Rahmen von Performance Measurement Systemen nachvollziehen können.	**Arbeitsaufwand:** Präsenzzeit: 42 Stunden Selbststudium: 138 Stunden

Lehrveranstaltungen: **1. Management Accounting** (Vorlesung) *Inhalte*: Die Veranstaltung befasst sich mit wesentlichen Aspekten der Performancemessung unternehmerischer Aktivitäten mit dem Fokus auf einer wertorientierten Perspektive. Die Veranstaltung ist in vier Hauptkapitel gegliedert. Zuerst werden Grundlagen des Management Accounting und der wertorientierten Unternehmensführung diskutiert. Auf dieser Basis werden Ansätze für die kapitalmarkt- und bilanzorientierte Performancemessung vorgestellt und deren Grenzen aufgezeigt. Darauffolgend werden die konzeptionellen Grundlagen eines ganzheitlichen Value Based Managements und die entsprechenden Dimensionen einer konsistenten Implementierung vorgestellt. Danach erfolgt eine Einbettung dieser wertorientierten Ansätze in die Ausgestaltung von Performance Measurement Systemen.	2 SWS
2. Management Accounting (Übung) *Inhalte*: Die Übung dient dazu die Konzepte der wertorientierten Unternehmensführung auf praktische Fragestellungen anzuwenden, indem Übungsaufgaben gelöst und die Inhalte an praktischen Beispielen diskutiert werden. Thematisch werden zunächst die Methoden der Unternehmensbewertung und deren Eignung für eine Wertorientiertes Steuerungssystem diskutiert. Darauf werden traditionelle Kennzahlenkonzepte vorgestellt und mögliche Nachteile aufgezeigt. Auf dieser Basis werden die methodischen Grundlagen von Wertorientierten Kennzahlen erörtert und deren Potentiale aufgezeigt. Zum Abschluss wird die Eignung der ganzheitlichen Implementierung von Value Based Management diskutiert.	1 SWS

Prüfung: Klausur (90 Minuten)	6 C

Prüfungsanforderungen: Nachweis von Kenntnissen der Konzepte, Dimensionen und Grenzen der Kapitalmarkt- und bilanzorientierte Performancemessung sowie des Value-Based Managements durch nennen, erläutern und berechnen in entsprechenden Aufgaben. Außerdem das Anwenden des erworbenen Wissens auf praxisnahe Aufgabenstellungen.	

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Grundkenntnisse in Controlling
Sprache: Deutsch	**Modulverantwortliche[r]:** Prof. Dr. Michael Wolff
Angebotshäufigkeit: jedes Wintersemester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 2
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen **Modul M.WIWI-BWL.0034: Logistik- und Supply Chain Management** *English title: Logistics and Supply Chain Management*	6 C 3 SWS

Lernziele/Kompetenzen: Die Studierenden • kennen die Teilbereiche und Funktionen der Logistik sowie des Supply Chain Managements und können diese klassifizieren • kennen den Begriff „Standortplanung", können dessen Teilgebiete definieren und verschiedene OR-Modelle und Verfahren zur Standortbestimmung anwenden • können das klassische Transportproblem erläutern und kennen dessen graphentheoretische Grundlagen • kennen verschiedene Lösungsalgorithmen für das Transportproblem und können diese auch auf Sonderformen des klassischen Transportproblems anwenden • kennen die Ausgestaltungsformen von Supply Chains und das SCOR-Modell • können Produkt- und Prozessdesign voneinander abgrenzen • kennen mögliche Formen der Vertragsgestaltung im Supply Chain Management • kennen die verschiedenen Modelle der Bestellplanung und die Bestellregeln • können statische Lagerhaltungsmodelle interpretieren und anwenden • können dynamische Modelle voneinander abgrenzen und anwenden	**Arbeitsaufwand:** Präsenzzeit: 42 Stunden Selbststudium: 138 Stunden

Lehrveranstaltungen: **1. Logistik- und Supply Chain Management** (Vorlesung) *Inhalte*: Inhaltlicher Schwerpunkt der Veranstaltung ist die Betrachtung der verschiedenen logistischen Strukturen und Probleme in und zwischen produzierenden Unternehmen. Dazu werden Quantitative Modelle vorgestellt und auf die Bereiche der Standortwahl, der Transportplanung, des Supply Chain Management und der Lagerhaltung angewendet.	2 SWS
2. Logistik- und Supply Chain Management (Übung)	1 SWS
Prüfung: Klausur (90 Minuten) **Prüfungsanforderungen:** Die Studierenden weisen in der Prüfung Kenntnisse in den folgenden Bereichen nach: • Grundlagen logistischer Problemstellungen • Standortplanung • Transportplanung • Supply Chain Management • Lagerhaltungsmodelle • Anwendung der vorgestellten OR-Modelle und Algorithmen auf die Problemstellungen der obigen Teilbereiche	6 C

Zugangsvoraussetzungen: keine	**Empfohlene Vorkenntnisse:** Modul "Unternehmensplanung"
Sprache:	**Modulverantwortliche[r]:**

Deutsch	Prof. Dr. Jutta Geldermann
Angebotshäufigkeit: jedes 4. Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:** 1 - 4
Maximale Studierendenzahl: nicht begrenzt	

Georg-August-Universität Göttingen	6 C
Module M.WIWI-QMW.0004: Econometrics I	6 WLH

Learning outcome, core skills:	**Workload:**
This course enables students to approach empirical research problems within the framework of the linear regression model, including model specification and selection, estimation, inference and detection of heteroscedasticity and autocorrelation. Moreover, the students can apply the methods discussed to real economic data and problems using the statistical software package R and they are able to assess estimator properties (finite sample and asymptotic). This course enables students to access more advanced topics in econometrics.	Attendance time: 56 h Self-study time: 124 h

Courses:	
1. Econometrics I (Lecture)	2 WLH
Contents:	
The lecture covers the following topics:	
1. Introduction to the basic multiple regression model, model specification, OLS estimation, prediction and model selection, Multicollinearity and partial regression. 2. The normal linear model, including maximum likelihood and interval estimation, hypothesis testing. 3. Asymptotic properties of the OLS and (E)GLS estimators. 4. Generalized linear model: GLS and EGLS estimators, properties of these, heteroskedastic and autocorrelated models, testing for heteroscedasticity and autocorrelation.	
2. Econometrics I (Exercise)	2 WLH
Contents:	
The practical deepens the understanding of the lecture topics by applying the methods from the lecture to economic problems and data, and reviewing and intensify theoretical concepts.	
3. Econometrics I (Tutorial)	2 WLH
Contents:	
The tutorials are small classes with max. 20 students, which give room for applying the concepts to specific problem sets and discussing questions, that students might encounter regarding the concepts addressed in the lecture and practical. A part of the tutorial are hands-on computer exercises using the software R. This enables students to conduct regression analysis in practice and prepares them for others (applied) courses.	

Examination: Written examination (90 minutes)	6 C

Examination requirements:	
The students demonstrate their understanding of basic econometric concepts. They show that they can apply these concepts to real economic problems.	

Admission requirements:	**Recommended previous knowledge:**
none	Module B.WIWI-OPH.0006: Statistics and module B.WIWI-OPH.0002: Mathematics

Language: English	**Person responsible for module:** Prof. Dr. Helmut Herwartz
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	6 C
Module M.WIWI-QMW.0009: Introduction to Time Series Analysis	4 WLH

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

Courses:	
1. 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
2. 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:** Module B.WIWI-OPH.0006: Statistics and module 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:	**Recommended semester:**

twice	2 - 3
Maximum number of students: 50	

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

Courses:	
1. 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
2. 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:** Module B.WIWI-OPH.0006: Statistics, module M.WIWI-QMW.0004: Econometrics I and module 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 | 6 C |
| **Module M.WIWI-VWL.0041: Panel Data Econometrics** | 4 WLH |

Learning outcome, core skills:	**Workload:**
• This course aims to study panel data econometric techniques in an intuitive and practical way and to provide the skills and understanding to read and evaluate empirical literature and to carry out empirical research. Empirical evaluation of economic models is an important feature of the study and application of economics. • The course is concerned with the *application* of econometric methods, with little emphasis on the mathematical aspects of the subject (which may be studied in other modules). The computer software package STATA will be used for practical work. Previous knowledge of intermediate econometrics is required.	Attendance time: 56 h Self-study time: 124 h

Courses:	
1. Panel Data Econometrics (Lecture)	2 WLH

Contents:

Linear Panel Data Models

1. Static Linear Panel Data Models

      1.1 Introduction to Panel Data

      1.2 Assumptions

      1.3 Estimation and Testing

            1.3.1 Pooled OLS

            1.3.2 Random Effects Estimation

            1.3.3 Fixed Effects Estimation. Testing for Serial Correlation

            1.3.4 First-Differencing Estimation

      1.4. Comparison of Estimators and Testing the Assumptions

      1.5 Correlated Random Effects (CRE) or Mundlak's Approach

2. Endogeneity and Dynamics in Linear Panel Data Models

      2.1. Equivalence Between GMM 3SLS and Standard Estimators

      2.2 Chamberlain's Approach to UE Models

      2.3. RE and FE Instrumental Variables Methods

      2.4. Hausman and Taylor Models

      2.5. First Differencing and IV

      2.6. Dynamic Panel Data Models. Estimation under Sequential Exogeneity

3. Special Topics

      3.1 Heterogeneous Panels

      3.2 Random Trend Models

      3.3 General Models with Specific Slopes

3.4 Robustness of Standard Fixed Effects Estimators
 	
3.5 Testing for Correlated Random Slopes
 	
Non-linear Panel Data Models
 	
4. Panel Data Models for Discrete Variables
 	
    4.1 Introduction. Binary Response Panel Data Models with Strictly Exogenous Variables
 	
    4.2 Linear Probability Model
 	
    4.3 Fixed versus Random Effects
 	
    4.4 Other issues: Endogenous explanatory   variables/Selection Bias
 	
The course is organized as a series of lectures complemented with tutorials.	

2. Panel Data Econometrics (Tutorial) *Contents*: The computer software package STATA will be used for practical work.	2 WLH

Examination: Written examination (120 minutes)	4 C

Examination: Term Paper (max. 10 pages, based on the tutorial)	2 C

Examination requirements: • Show a deep knowledge of the econometric techniques covered in the course • Show ability to select the adequate econometric model for a give economic empirical application • Understanding of the economic logic behind the panel data models introduced in the course • Being able to interpret tables of empirical results available in published economic research	

Admission requirements: none	**Recommended previous knowledge:** Econometrics I
Language: English	**Person responsible for module:** Prof. Dr. Inmaculada Martinez-Zarzoso
Course frequency: each summer semester	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 2 - 4
Maximum number of students: 30	

Georg-August-Universität Göttingen **Module M.WIWI-VWL.0128: Deep Determinants of Growth and Development**	6 C 4 WLH

Learning outcome, core skills: Students should acquire a deeper understanding of the mechanisms that lead to long-run economic development. They should learn about the forces that are linked to economic development like demography, education, and fundamental determinants of economic growth like culture, institutions, geography.	**Workload:** Attendance time: 56 h Self-study time: 124 h

Course: Deep Determinants of Growth and Development (Lecture) *Contents*: In this course, we will study long-run trends in economic development. We will analyze questions such as • Why are some countries richer than others? • Why is a country today richer than several generations ago? • How can historical events affect the economy today? • What are the mechanisms that lead to the transition from stagnation towards sustained growth? Contents: 1) (Bio-)Geography and Economic Development 2) Institutions 3) Government 4) Culture and Economic Development 5) The Deep Roots of Economic Development 6) Population and Economic Growth 7) Economic Growth in the Very Long Run	2 WLH
Examination: Oral exam (ca. 20 minutes) or written exam (90 minutes)	6 C

Course: Deep Determinants of Growth and Development (Tutorial) *Contents*: In the accompanying tutorials, students should discuss and solve problem sets to deepen and broaden their knowledge of the topics covered in the lectures.	2 WLH

Examination requirements: Demonstrate: • a profound knowledge of the causes and consequences of long-run economic development • a deep understanding of standard models of economic growth • the ability to solve problems in a verbal, graphical and analytical manner	

Admission requirements: none	**Recommended previous knowledge:**

	Macroeconomics, Mathematics for Economists, Economic Growth, Econometrics as taught in the Bachelor courses
Language: English	**Person responsible for module:** Dr. Katharina Werner
Course frequency: irregular	**Duration:** 1 semester[s]
Number of repeat examinations permitted: twice	**Recommended semester:** 1 - 4
Maximum number of students: not limited	

Georg-August-Universität Göttingen	6 C
Modul SK.FS.EN-FW-C1-1: Business English I - C1.1 *English title: Business English I - C1.1*	4 SWS

Lernziele/Kompetenzen:	**Arbeitsaufwand:**
Weiterentwicklung bereits vorhandener diskursiver Fertigkeiten und Kompetenzen auf einem über die Stufe B2 des *Gemeinsamen europäischen Referenzrahmens für Sprachen* hinausgehenden Niveau, mit Hilfe derer auch jede Art von beruflicher und wirtschaftswissenschaftlicher Sprachhandlung auf Englisch vollzogen werden kann, wie z.B.:	Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

- Fähigkeit, mühelos an allen Unterhaltungen, Diskussionen und Verhandlungen mit allgemeinen und wirtschaftsbezogenen Inhalten teilzunehmen und dabei die Gesprächspartner problemlos zu verstehen sowie auf ihre Beiträge differenziert einzugehen bzw. eigene Beiträge inhaltlich komplex und sprachlich angemessen zu formulieren;
- Fähigkeit, auch umfangreichere wirtschaftsbezogene Publikationen zu allen Themen zu verstehen und unter Anwendung spezifischer Sprachstrukturen und -konventionen sprachlich und stilistisch sicher selbst zu verfassen;
- Erwerb spezifischer sprachlicher und stilistischer Strukturen der englischen Sprache sowie Entwicklung eines differenzierten wirtschaftswissenschaftlichen Wortschatzes;
- Ausbau des operativen landeskundlichen und interkulturellen Wissens über die englischsprachigen Länder im beruflichen und wirtschaftlichen Kontext.

Lehrveranstaltung: Business English I (Übung) *Inhalte*:	4 SWS

- Management
- Company Organisational Structures
- Business Entities
- Sectors of the Economy
- Production and Products
- Marketing
- Advertising
- Banking
- Venture Capital
- Market Structure
- Competition

In der Lehrveranstaltung werden die vier Sprachfertigkeiten praktisch geübt. Der Kompetenzzuwachs basiert auf Self Assessment, Peer Assessment und dem Feedback der Lehrkraft zu den von den Studierenden erstellten sprachlichen Produkten bzw. bearbeiteten Aufgaben.

Prüfung: (1) Portfolio: 2 mündl. Arbeitsaufträge (ca. 15 Min. - mündl. Ausdruck 25 %) und 2-3 schriftl. Arbeitsaufträge (insg. max. 1000 Wörter - schriftl. Ausdruck 25 %); sowie (2) schriftl. Prüfung (insg. 90 Min. - Lese- und Hörverstehen jeweils 25 %)	6 C

Prüfungsvorleistungen:

regelmäßige und aktive Teilnahme

Prüfungsanforderungen:

Nachweis von sprachlichen Handlungskompetenzen in interkulturellen und wirtschaftsbezogenen Kontexten unter Anwendung der vier Fertigkeiten Hören, Sprechen, Lesen und Schreiben, d.h. Nachweis der Fähigkeit, rezeptiv wie produktiv auf eine über das Niveau B2 des *Gemeinsamen europäischen Referenzrahmens für Sprachen* hinausgehende Art mit für Wirtschaftswissenschaftlerinnen und Wirtschaftswissenschaftler typischen mündlichen und schriftlichen Kommunikationssituationen im Kontext von Studium, Forschung und Beruf umzugehen.

Zugangsvoraussetzungen: Modul Mittelstufe II oder Einstufungstest mit abgeschlossenem Niveau B2.2 des GER	**Empfohlene Vorkenntnisse:** keine
Sprache: Englisch	**Modulverantwortliche[r]:** Ashley Chandler
Angebotshäufigkeit: jedes Semester	**Dauer:** 1 Semester
Wiederholbarkeit: zweimalig	**Empfohlenes Fachsemester:**
Maximale Studierendenzahl: 25	

Georg-August-Universität Göttingen **Modul SK.FS.EN-FW-C1-2: Business English II - C1.2** *English title: Business English II - C1.2*	6 C 4 SWS

Lernziele/Kompetenzen: Weiterentwicklung vorhandener diskursiver Fertigkeiten und Kompetenzen bis zum Niveau C1 des *Gemeinsamen europäischen Referenzrahmens für Sprachen*, mit Hilfe derer auch sehr komplexe berufliche und wirtschaftswissenschaftliche Sprachhandlungen auf Englisch vollzogen werden können, wie z.B.: • Weiterentwicklung der Fähigkeit, mühelos an allen Unterhaltungen, Diskussionen und Verhandlungen mit allgemeinen und wirtschaftsbezogenen Inhalten teilzunehmen, solche mündlichen Kommunikationssituationen zu leiten bzw. aktiv mitzugestalten sowie eigene Beiträge inhaltlich komplex und sprachlich angemessen zu formulieren; • Weiterentwicklung der Fähigkeit, auch umfangreichere wirtschaftsbezogene Publikationen zu allen Themen zu verstehen und unter Anwendung spezifischer Sprachstrukturen und -konventionen sprachlich und stilistisch sicher auf einem hohen Niveau selbst zu verfassen; • ergänzender Erwerb spezifischer sprachlicher und stilistischer Strukturen der englischen Sprache sowie Weiterentwicklung eines differenzierten wirtschaftswissenschaftlichen Wortschatzes; • Ausbau des operativen landeskundlichen und interkulturellen Wissens über die englischsprachigen Länder im beruflichen und wirtschaftlichen Kontext.	**Arbeitsaufwand:** Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden

Lehrveranstaltung: Business English II (Übung) *Inhalte*: • Stock Exchanges • Bonds and Derivatives • Takeovers, Mergers and Buyouts • The Role of Government • Taxation • Central Banking • Economic Growth • The Business Cycle • Keynesianism and Monetarism • Efficiency • Employment • Exchange Rates • International Trade In der Lehrveranstaltung werden die vier Sprachfertigkeiten praktisch geübt. Der Kompetenzzuwachs basiert auf Self Assessment, Peer Assessment und dem Feedback der Lehrkraft zu den von den Studierenden erstellten sprachlichen Produkten bzw. bearbeiteten Aufgaben.	4 SWS
Prüfung: (1) Portfolio: 2 mündl. Arbeitsaufträge (ca. 15 Min. - mündl. Ausdruck 25 %) und 2-3 schriftl. Arbeitsaufträge (insg. max. 1000 Wörter - schriftl. Ausdruck 25	6 C

%); sowie (2) schriftl. Prüfung (insg. 90 Min. - Lese- und Hörverstehen jeweils 25 %)

Prüfungsvorleistungen:

regelmäßige und aktive Teilnahme

Prüfungsanforderungen:

Nachweis von sprachlichen Handlungskompetenzen in interkulturellen und wirtschaftsbezogenen Kontexten unter Anwendung der vier Fertigkeiten Hören, Sprechen, Lesen und Schreiben, d.h. Nachweis der Fähigkeit, rezeptiv wie produktiv auf eine dem Niveau C1 des *Gemeinsamen europäischen Referenzrahmens für Sprachen* angemessene Art mit für Wirtschaftswissenschaftlerinnen und Wirtschaftswissenschaftler typischen mündlichen und schriftlichen Kommunikationssituationen im Kontext von Studium, Forschung und Beruf umzugehen.

Zugangsvoraussetzungen:	**Empfohlene Vorkenntnisse:**
Modul Business English I	keine
Sprache:	**Modulverantwortliche[r]:**
Englisch	Ashley Chandler
Angebotshäufigkeit:	**Dauer:**
jedes Semester	1 Semester
Wiederholbarkeit:	**Empfohlenes Fachsemester:**
zweimalig	
Maximale Studierendenzahl:	
25	