

# **Modulverzeichnis**

**zu der Prüfungs- und Studienordnung für  
den konsekutiven Master-Studiengang  
"Mathematik" (Amtliche Mitteilungen I Nr.  
14/2013 S. 313, zuletzt geändert durch  
Amtliche Mitteilungen I Nr. 6/2023 S. 143)**

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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 a 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 key competencies modules offered by the Unit Mathematics, according to the regulations in No. IV. "Key competencies in the graduate programme in Mathematics", or 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 den unter IV. "Schlüsselkompetenzmodule im Masterstudium" genannten Wahlmodulen aus dem Angebot der Lehreinheit Mathematik oder 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 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 3 or SP 4, elective 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 key competencies modules offered by the Unit Mathematics, according to the regulations in No. IV. "Key competencies in the graduate programme in Mathematics", or 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 Lehrinheit Mathematik erfolgreich zu absolvieren. Ferner können Module aus den unter IV. "Schlüsselkompetenzmodule im Masterstudium" genannten Wahlmodulen aus dem Angebot der Lehrinheit Mathematik oder aus dem universitätsweiten Schlüsselkompetenzangebot frei 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.

## **3. 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. In the study track "Mathematical Data Science" the study foci SP 3 or SP 4 are permitted as study focus of the Master's thesis, only.

Im forschungsorientierten Studienprofil MDS "Mathematical Data Science" sind Module nach Maßgabe der nachstehenden Bestimmungen erfolgreich zu absolvieren. Als Schwerpunkt der Masterarbeit sind im Studienprofil Mathematical Data Science nur die Schwerpunkte SP 3 oder SP 4 zugelassen.

### **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 Oberseminar Modul im Umfang von wenigstens 3 C, aus den folgenden Zyklen absolviert werden.

- Inverse problems
- 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 Oberseminar Modul 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. 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:

- M.Mat.0731: Advanced practical course in scientific computing (10 C, 4 SWS)..... 1031
- M.Mat.0741: Advanced practical course in stochastics (10 C, 6 SWS)..... 1033

### dd. Computer science

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.

- B.Inf.1236: Machine Learning (6 C, 4 SWS)..... 797
- B.Inf.1237: Deep Learning (6 C, 4 SWS)..... 798
- B.Inf.1240: Visualization (5 C, 3 SWS)..... 799
- B.Inf.1241: Computational Optimal Transport (6 C, 4 SWS)..... 800
- M.Inf.1112: Effiziente Algorithmen (5 C, 3 SWS)..... 1000
- M.Inf.1141: Semistrukturierte Daten und XML (6 C, 4 SWS)..... 1001



M.Inf.1151: Vertiefung Softwaretechnik: Data Science und Big Data Analytics (5 C, 3 SWS).....	1002
M.Inf.1171: Cloud and Service Computing (5 C, 3 SWS).....	1003
M.Inf.1172: Using Research Infrastructures (5 C, 3 SWS).....	1005
M.Inf.1185: Sensor Data Fusion (5 C, 4 SWS).....	1007
M.Inf.1186: Seminar Hot Topics in Data Fusion and Analytics (5 C, 2 SWS).....	1009
M.Inf.1188: Mobile Robotics (5 C, 4 SWS).....	1010
M.Inf.1210: Seminar Algorithmische Methoden und theoretische Konzepte (5 C, 2 SWS)....	1011
M.Inf.1211: Probabilistische Datenmodelle und ihre Anwendungen (6 C, 4 SWS).....	1012
M.Inf.1213: Algorithmisches Lernen und Mustererkennung (6 C, 4 SWS).....	1013
M.Inf.1216: Datenkompression und Informationstheorie (6 C, 4 SWS).....	1014
M.Inf.1231: Spezialisierung Verteilte Systeme (6 C, 4 SWS).....	1016
M.Inf.1232: Parallel Computing (6 C, 4 SWS).....	1018
M.Inf.1244: Seminar on optimal transport (5 C, 2 SWS).....	1020
M.Inf.1268: Informationstheorie (6 C, 4 SWS).....	1021
M.Inf.1802: Praktikum XML (6 C, 4 SWS).....	1022
M.Inf.1806: Projektseminar Datenbanken und Informationssysteme (6 C, 2 SWS).....	1023
M.Inf.1808: Practical Course on Parallel Computing (6 C, 4 SWS).....	1024
M.Inf.2102: Advanced Statistical Learning for Data Science (6 C, 4 SWS).....	1026
M.Inf.2201: Probabilistic Machine Learning (9 C, 6 SWS).....	1028
M.Inf.2241: Current Topics in Machine Learning (5 C, 2 SWS).....	1030

## ee. 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.dd) "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.dd) "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.dd) "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.dd) "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, according to the regulations in No. IV. "Key competencies in the graduate programme in Mathematics", or from the modules according to section dd. "Computer science" has to be completed successfully.

Further modules may be chosen freely from the key competencies modules offered by the Unit Mathematics, according to the regulations in No. IV. "Key competencies in the graduate programme in Mathematics", or 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 Modul aus den in Nr. IV) "Schlüsselkompetenzmodule im Masterstudium" genannten Wahlmodulen aus dem Angebot der Lehreinheit Mathematik oder aus den im Abschnitt iv) „Informatik“ gelisteten Modulen zu belegen.

Ferner können weitere Module aus den unter IV. "Schlüsselkompetenzmodule im Masterstudium" genannten Wahlmodulen aus dem Angebot der Lehreinheit Mathematik oder aus dem universitätsweiten Schlüsselkompetenzangebot frei 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"**

M.Mat.3110: Higher analysis (9 C, 6 SWS)..... 1036

B.Mat.3111: Introduction to analytic number theory (9 C, 6 SWS).....850

B.Mat.3112: Introduction to analysis of partial differential equations (9 C, 6 SWS).....852

B.Mat.3113: Introduction to differential geometry (9 C, 6 SWS).....854

B.Mat.3114: Introduction to algebraic topology (9 C, 6 SWS)..... 856

B.Mat.3115: Introduction to mathematical methods in physics (9 C, 6 SWS)..... 858

B.Mat.3311: Advances in analytic number theory (9 C, 6 SWS)..... 898

B.Mat.3312: Advances in analysis of partial differential equations (9 C, 6 SWS).....900

B.Mat.3313: Advances in differential geometry (9 C, 6 SWS).....902

B.Mat.3314: Advances in algebraic topology (9 C, 6 SWS)..... 904

B.Mat.3315: Advances in mathematical methods in physics (9 C, 6 SWS).....906

M.Mat.4511: Specialisation in analytic number theory (9 C, 6 SWS)..... 1042

M.Mat.4512: Specialisation in analysis of partial differential equations (9 C, 6 SWS).....	1044
M.Mat.4513: Specialisation in differential geometry (9 C, 6 SWS).....	1046
M.Mat.4514: Specialisation in algebraic topology (9 C, 6 SWS).....	1048
M.Mat.4515: Specialisation in mathematical methods in physics (9 C, 6 SWS).....	1050
M.Mat.4611: Aspects of analytic number theory (6 C, 4 SWS).....	1090
M.Mat.4612: Aspects of analysis of partial differential equations (6 C, 4 SWS).....	1092
M.Mat.4613: Aspects of differential geometry (6 C, 4 SWS).....	1094
M.Mat.4614: Aspects of algebraic topology (6 C, 4 SWS).....	1096
M.Mat.4615: Aspects of mathematical methods in physics (6 C, 4 SWS).....	1098
M.Mat.4711: Special course in analytic number theory (3 C, 2 SWS).....	1138
M.Mat.4712: Special course in analysis of partial differential equations (3 C, 2 SWS).....	1140
M.Mat.4713: Special course in differential geometry (3 C, 2 SWS).....	1142
M.Mat.4714: Special course in algebraic topology (3 C, 2 SWS).....	1144
M.Mat.4715: Special course in mathematical methods in physics (3 C, 2 SWS).....	1146
M.Mat.4811: Seminar on analytic number theory (3 C, 2 SWS).....	1186
M.Mat.4812: Seminar on analysis of partial differential equations (3 C, 2 SWS).....	1188
M.Mat.4813: Seminar on differential geometry (3 C, 2 SWS).....	1190
M.Mat.4814: Seminar on algebraic topology (3 C, 2 SWS).....	1192
M.Mat.4815: Seminar on mathematical methods in physics (3 C, 2 SWS).....	1194
M.Mat.4911: Advanced seminar on analytic number theory (3 C, 2 SWS).....	1234
M.Mat.4912: Advanced seminar on analysis of partial differential equations (3 C, 2 SWS).....	1236
M.Mat.4913: Advanced seminar on differential geometry (3 C, 2 SWS).....	1238
M.Mat.4914: Advanced seminar on algebraic topology (3 C, 2 SWS).....	1240
M.Mat.4915: Advanced seminar on mathematical methods in physics (3 C, 2 SWS).....	1242

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

B.Mat.3121: Introduction to algebraic geometry (9 C, 6 SWS).....	860
B.Mat.3122: Introduction to algebraic number theory (9 C, 6 SWS).....	862
B.Mat.3123: Introduction to algebraic structures (9 C, 6 SWS).....	864
B.Mat.3124: Introduction to groups, geometry and dynamical systems (9 C, 6 SWS).....	866

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B.Mat.3125: Introduction to non-commutative geometry (9 C, 6 SWS).....	868
B.Mat.3321: Advances in algebraic geometry (9 C, 6 SWS).....	908
B.Mat.3322: Advances in algebraic number theory (9 C, 6 SWS).....	910
B.Mat.3323: Advances in algebraic structures (9 C, 6 SWS).....	912
B.Mat.3324: Advances in groups, geometry and dynamical systems (9 C, 6 SWS).....	914
B.Mat.3325: Advances in non-commutative geometry (9 C, 6 SWS).....	916
M.Mat.4521: Specialisation in algebraic geometry (9 C, 6 SWS).....	1052
M.Mat.4522: Specialisation in algebraic number theory (9 C, 6 SWS).....	1054
M.Mat.4523: Specialisation in algebraic structures (9 C, 6 SWS).....	1056
M.Mat.4524: Specialisation in groups, geometry and dynamical systems (9 C, 6 SWS).....	1058
M.Mat.4525: Specialisation in non-commutative geometry (9 C, 6 SWS).....	1060
M.Mat.4621: Aspects of algebraic geometry (6 C, 4 SWS).....	1100
M.Mat.4622: Aspects of algebraic number theory (6 C, 4 SWS).....	1102
M.Mat.4623: Aspects of algebraic structures (6 C, 4 SWS).....	1104
M.Mat.4624: Aspects of groups, geometry and dynamical systems (6 C, 4 SWS).....	1106
M.Mat.4625: Aspects of non-commutative geometry (6 C, 4 SWS).....	1108
M.Mat.4721: Special course in algebraic geometry (3 C, 2 SWS).....	1148
M.Mat.4722: Special course in algebraic number theory (3 C, 2 SWS).....	1150
M.Mat.4723: Special course in algebraic structures (3 C, 2 SWS).....	1152
M.Mat.4724: Special course in groups, geometry and dynamical systems (3 C, 2 SWS).....	1154
M.Mat.4725: Special course in non-commutative geometry (3 C, 2 SWS).....	1156
M.Mat.4821: Seminar on algebraic geometry (3 C, 2 SWS).....	1196
M.Mat.4822: Seminar on algebraic number theory (3 C, 2 SWS).....	1198
M.Mat.4823: Seminar on algebraic structures (3 C, 2 SWS).....	1200
M.Mat.4824: Seminar on groups, geometry and dynamical systems (3 C, 2 SWS).....	1202
M.Mat.4825: Seminar on non-commutative geometry (3 C, 2 SWS).....	1204
M.Mat.4921: Advanced seminar on algebraic geometry (3 C, 2 SWS).....	1244
M.Mat.4922: Advanced seminar on algebraic number theory (3 C, 2 SWS).....	1246
M.Mat.4923: Advanced seminar on algebraic structures (3 C, 2 SWS).....	1248
M.Mat.4924: Advanced seminar on groups, geometry and dynamical systems (3 C, 2 SWS).....	1250
M.Mat.4925: Advanced seminar on non-commutative geometry (3 C, 2 SWS).....	1252

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

M.Mat.0731: Advanced practical course in scientific computing (10 C, 4 SWS)..... 1031

M.Mat.3110: Higher analysis (9 C, 6 SWS)..... 1036

M.Mat.3130: Operations research (9 C, 6 SWS)..... 1038

B.Mat.3131: Introduction to inverse problems (9 C, 6 SWS).....870

B.Mat.3132: Introduction to approximation methods (9 C, 6 SWS)..... 872

B.Mat.3133: Introduction to numerics of partial differential equations (9 C, 6 SWS)..... 874

B.Mat.3134: Introduction to optimisation (9 C, 6 SWS)..... 876

B.Mat.3137: Introduction to variational analysis (9 C, 6 SWS).....878

B.Mat.3138: Introduction to image and geometry processing (9 C, 6 SWS)..... 880

B.Mat.3139: Introduction to scientific computing / applied mathematics (9 C, 6 SWS)..... 882

B.Mat.3331: Advances in inverse problems (9 C, 6 SWS)..... 918

B.Mat.3332: Advances in approximation methods (9 C, 6 SWS)..... 920

B.Mat.3333: Advances in numerics of partial differential equations (9 C, 6 SWS)..... 922

B.Mat.3334: Advances in optimisation (9 C, 6 SWS)..... 924

B.Mat.3337: Advances in variational analysis (9 C, 6 SWS)..... 926

B.Mat.3338: Advances in image and geometry processing (9 C, 6 SWS)..... 928

B.Mat.3339: Advances in scientific computing / applied mathematics (9 C, 6 SWS).....930

M.Mat.4531: Specialisation in inverse problems (9 C, 6 SWS)..... 1062

M.Mat.4532: Specialisation in approximation methods (9 C, 6 SWS)..... 1064

M.Mat.4533: Specialisation in numerical methods of partial differential equations (9 C, 6 SWS)..... 1066

M.Mat.4534: Specialisation in optimisation (9 C, 6 SWS)..... 1068

M.Mat.4537: Specialisation in variational analysis (9 C, 6 SWS)..... 1070

M.Mat.4538: Specialisation in image and geometry processing (9 C, 6 SWS).....1072

M.Mat.4539: Specialisation in scientific computing / applied mathematics (9 C, 6 SWS).....1074

M.Mat.4631: Aspects of inverse problems (6 C, 4 SWS)..... 1110

M.Mat.4632: Aspects of approximation methods (6 C, 4 SWS)..... 1112

M.Mat.4633: Aspects of numerical methods of partial differential equations (6 C, 4 SWS)..... 1114

M.Mat.4634: Aspects of optimisation (6 C, 4 SWS)..... 1116

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M.Mat.4637: Aspects of variational analysis (6 C, 4 SWS).....	1118
M.Mat.4638: Aspects of image and geometry processing (6 C, 4 SWS).....	1120
M.Mat.4639: Aspects of scientific computing / applied mathematics (6 C, 4 SWS).....	1122
M.Mat.4731: Special course in inverse problems (3 C, 2 SWS).....	1158
M.Mat.4732: Special course in approximation methods (3 C, 2 SWS).....	1160
M.Mat.4733: Special course in numerical methods of partial differential equations (3 C, 2 SWS)....	1162
M.Mat.4734: Special course in optimisation (3 C, 2 SWS).....	1164
M.Mat.4737: Special course in variational analysis (3 C, 2 SWS).....	1166
M.Mat.4738: Special course in image and geometry processing (3 C, 2 SWS).....	1168
M.Mat.4739: Special course in scientific computing / applied mathematics (3 C, 2 SWS).....	1170
M.Mat.4831: Seminar on inverse problems (3 C, 2 SWS).....	1206
M.Mat.4832: Seminar on approximation methods (3 C, 2 SWS).....	1208
M.Mat.4833: Seminar on numerical methods of partial differential equations (3 C, 2 SWS).....	1210
M.Mat.4834: Seminar on optimisation (3 C, 2 SWS).....	1212
M.Mat.4837: Seminar on variational analysis (3 C, 2 SWS).....	1214
M.Mat.4838: Seminar on image and geometry processing (3 C, 2 SWS).....	1216
M.Mat.4839: Seminar on scientific computing / applied mathematics (3 C, 2 SWS).....	1218
M.Mat.4931: Advanced seminar on inverse problems (3 C, 2 SWS).....	1254
M.Mat.4932: Advanced seminar on approximation methods (3 C, 2 SWS).....	1256
M.Mat.4933: Advanced seminar on numerical methods of partial differential equations (3 C, 2 SWS).....	1258
M.Mat.4934: Advanced seminar on optimisation (3 C, 2 SWS).....	1260
M.Mat.4937: Advanced seminar on variational analysis (3 C, 2 SWS).....	1262
M.Mat.4938: Advanced seminar on image and geometry processing (3 C, 2 SWS).....	1264
M.Mat.4939: Advanced seminar on scientific computing / applied mathematics (3 C, 2 SWS).....	1266

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

M.Mat.0741: Advanced practical course in stochastics (10 C, 6 SWS).....	1033
B.Mat.3041: Overview on non-life insurance mathematics (3 C, 2 SWS).....	844
B.Mat.3042: Overview on life insurance mathematics (3 C, 2 SWS).....	845
B.Mat.3043: Non-life insurance mathematics (6 C, 4 SWS).....	846

B.Mat.3044: Life insurance mathematics (6 C, 4 SWS).....	848
M.Mat.3140: Mathematical statistics (9 C, 6 SWS).....	1040
B.Mat.3141: Introduction to applied and mathematical stochastics (9 C, 6 SWS).....	884
B.Mat.3142: Introduction to stochastic processes (9 C, 6 SWS).....	886
B.Mat.3143: Introduction to stochastic methods of econometrics (9 C, 6 SWS).....	888
B.Mat.3144: Introduction to mathematical statistics (9 C, 6 SWS).....	890
B.Mat.3145: Introduction to statistical modelling and inference (9 C, 6 SWS).....	892
B.Mat.3146: Introduction to multivariate statistics (9 C, 6 SWS).....	894
B.Mat.3147: Introduction to statistical foundations of data science (9 C, 6 SWS).....	896
B.Mat.3341: Advances in applied and mathematical stochastics (9 C, 6 SWS).....	932
B.Mat.3342: Advances in stochastic processes (9 C, 6 SWS).....	934
B.Mat.3343: Advances in stochastic methods of econometrics (9 C, 6 SWS).....	936
B.Mat.3344: Advances in mathematical statistics (9 C, 6 SWS).....	938
B.Mat.3345: Advances in statistical modelling and inference (9 C, 6 SWS).....	940
B.Mat.3346: Advances in multivariate statistics (9 C, 6 SWS).....	942
B.Mat.3347: Advances in statistical foundations of data science (9 C, 6 SWS).....	944
M.Mat.4541: Specialisation in applied and mathematical stochastics (9 C, 6 SWS).....	1076
M.Mat.4542: Specialisation in stochastic processes (9 C, 6 SWS).....	1078
M.Mat.4543: Specialisation in stochastic methods in econometrics (9 C, 6 SWS).....	1080
M.Mat.4544: Specialisation in mathematical statistics (9 C, 6 SWS).....	1082
M.Mat.4545: Specialisation in statistical modelling and inference (9 C, 6 SWS).....	1084
M.Mat.4546: Specialisation in multivariate statistics (9 C, 6 SWS).....	1086
M.Mat.4547: Specialisation in statistical foundations of data science (9 C, 6 SWS).....	1088
M.Mat.4641: Aspects of applied and mathematical stochastics (6 C, 4 SWS).....	1124
M.Mat.4642: Aspects of stochastic processes (6 C, 4 SWS).....	1126
M.Mat.4643: Aspects of stochastics methods of econometrics (6 C, 4 SWS).....	1128
M.Mat.4644: Aspects of mathematical statistics (6 C, 4 SWS).....	1130
M.Mat.4645: Aspects of statistical modelling and inference (6 C, 4 SWS).....	1132
M.Mat.4646: Aspects of multivariate statistics (6 C, 4 SWS).....	1134
M.Mat.4647: Aspects of statistical foundations of data science (6 C, 4 SWS).....	1136
M.Mat.4741: Special course in applied and mathematical stochastics (3 C, 2 SWS).....	1172

M.Mat.4742: Special course in stochastic processes (3 C, 2 SWS).....	1174
M.Mat.4743: Special course in stochastic methods of econometrics (3 C, 2 SWS).....	1176
M.Mat.4744: Special course in mathematical statistics (3 C, 2 SWS).....	1178
M.Mat.4745: Special course in statistical modelling and inference (3 C, 2 SWS).....	1180
M.Mat.4746: Special course in multivariate statistics (3 C, 2 SWS).....	1182
M.Mat.4747: Special course in statistical foundations of data science (3 C, 2 SWS).....	1184
M.Mat.4841: Seminar on applied and mathematical stochastics (3 C, 2 SWS).....	1220
M.Mat.4842: Seminar on stochastic processes (3 C, 2 SWS).....	1222
M.Mat.4843: Seminar on stochastic methods of econometrics (3 C, 2 SWS).....	1224
M.Mat.4844: Seminar on mathematical statistics (3 C, 2 SWS).....	1226
M.Mat.4845: Seminar on statistical modelling and inference (3 C, 2 SWS).....	1228
M.Mat.4846: Seminar on multivariate statistics (3 C, 2 SWS).....	1230
M.Mat.4847: Seminar on statistical foundations of data science (3 C, 2 SWS).....	1232
M.Mat.4941: Advanced seminar on applied and mathematical stochastics (3 C, 2 SWS).....	1268
M.Mat.4942: Advanced seminar on stochastic processes (3 C, 2 SWS).....	1270
M.Mat.4943: Advanced seminar on stochastic methods in econometrics (3 C, 2 SWS).....	1272
M.Mat.4944: Advanced seminar on mathematical statistics (3 C, 2 SWS).....	1274
M.Mat.4945: Advanced seminar on statistical modelling and inference (3 C, 2 SWS).....	1276
M.Mat.4946: Advanced seminar on multivariate statistics (3 C, 2 SWS).....	1278
M.Mat.4947: Advanced seminar on statistical foundations of data science (3 C, 2 SWS).....	1280

### 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.

B.Phy.1551: Introduction to Astrophysics (8 C, 6 SWS).....	961
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#### 2. Business Administration

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

Im Nebenfach "Betriebswirtschaftslehre" stehen folgende Module zur Auswahl:

B.WIWI-WIN.0001: Management der Informationssysteme (6 C, 3 SWS).....	991
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B.WIWI-WIN.0002: Management der Informationswirtschaft (6 C, 6 SWS).....	994
B.WIWI-BWL.0014: Rechnungslegung der Unternehmung (6 C, 4 SWS).....	968
B.WIWI-BWL.0023: Grundlagen der Versicherungstechnik (6 C, 2 SWS).....	969
B.WIWI-BWL.0038: Supply Chain Management (6 C, 2 SWS).....	971
B.WIWI-BWL.0087: International Marketing (6 C, 2 SWS).....	973
M.WIWI-BWL.0001: Finanzwirtschaft (6 C, 4 SWS).....	1289
M.WIWI-BWL.0002: Rechnungslegung nach IFRS (6 C, 4 SWS).....	1291
M.WIWI-BWL.0003: Unternehmensbesteuerung (6 C, 4 SWS).....	1293
M.WIWI-BWL.0004: Financial Risk Management (6 C, 4 SWS).....	1295
M.WIWI-BWL.0006: Seminar in Finanzwirtschaft (6 C, 2 SWS).....	1297
M.WIWI-BWL.0008: Derivate (6 C, 4 SWS).....	1298
M.WIWI-BWL.0023: Performance Management (6 C, 4 SWS).....	1300
M.WIWI-BWL.0034: Logistik- und Supply Chain Management (6 C, 3 SWS).....	1302
M.WIWI-BWL.0133: Banking Supervision (6 C, 2 SWS).....	1304
M.WIWI-BWL.0134: Panel Data Analysis in Marketing (6 C, 2 SWS).....	1306
M.WIWI-QMW.0002: Advanced Statistical Inference (Likelihood & Bayes) (6 C, 4 SWS).....	1307
M.WIWI-QMW.0009: Introduction to Time Series Analysis (6 C, 4 SWS).....	1312
M.WIWI-QMW.0012: Multivariate Time Series Analysis (6 C, 4 SWS).....	1314

### 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.

M.Che.1311: Schwingungsspektroskopie und zwischenmolekulare Dynamik (6 C, 4 SWS).....	996
M.Che.1313: Elektronische Spektroskopie und Reaktionsdynamik (6 C, 4 SWS).....	997
M.Che.1314: Biophysikalische Chemie (6 C, 5 SWS).....	998
M.Che.1315: Chemical Dynamics at Surfaces (6 C, 4 SWS).....	999

### 4. Computer Science

**a.**

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: Grundlagen der Informatik und Programmierung
- B.Inf.1102: Grundlagen der Praktischen Informatik
- B.Inf.1801: Programmierkurs

**b.**

In addition, following modules may be chosen.

Weiterhin können folgende Module eingebracht werden.

B.Phy.5601: Theoretical and Computational Neuroscience I (3 C, 2 SWS).....	962
B.Phy.5602: Theoretical and Computational Neuroscience II (3 C, 2 SWS).....	963
B.Phy.5651: Advanced Computational Neuroscience (3 C, 2 SWS).....	964
B.Phy.5652: Advanced Computational Neuroscience II (3 C, 2 SWS).....	965
B.Phy.5676: Computer Vision and Robotics (9 C, 6 SWS).....	966
M.Phy.5601: Seminar Computational Neuroscience/Neuroinformatik (4 C, 2 SWS).....	1288

**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. Advanced studies modules may be chosen after the respective basic studies module has successfully been completed, only.

Im Nebenfach "Philosophie" stehen folgende Module zur Auswahl; in einem der gewählten Module muss eine Hausarbeit angefertigt werden. Aufbaumodule dürfen nur belegt werden, wenn zuvor die entsprechenden Basismodule erfolgreich abgeschlossen wurden.

B.Phi.01: Basismodul Theoretische Philosophie (9 C, 4 SWS).....	946
B.Phi.02: Basismodul Praktische Philosophie (9 C, 4 SWS).....	948
B.Phi.03: Basismodul Geschichte der Philosophie (9 C, 4 SWS).....	950
B.Phi.05: Aufbaumodul Theoretische Philosophie (10 C, 4 SWS).....	952
B.Phi.06: Aufbaumodul Praktische Philosophie (10 C, 4 SWS).....	954
B.Phi.07: Aufbaumodul Geschichte der Philosophie (10 C, 4 SWS).....	956
B.Phi.18a: Vertiefte Bearbeitung philosophischer Themen für HörerInnen aller Fächer (6 C, 2 SWS).....	958
B.Phi.19a: Spezielle Themen der Philosophie für HörerInnen aller Fächer (3 C, 2 SWS).....	960
M.Phi.101: Ausgewählte Themen der Theoretischen Philosophie (9 C, 4 SWS).....	1282
M.Phi.102: Ausgewählte Themen der Praktischen Philosophie (9 C, 4 SWS).....	1284

M.Phi.103: Ausgewählte Themen der Geschichte der Philosophie (9 C, 4 SWS)..... 1286

## 6. Physics

In "Physics" as a minor subject all modules with module number B.Phy.\*\*\*\* or M.Phy.\*\*\* can be chosen, with the exception 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 nicht 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:

B.WIWI-BWL.0023: Grundlagen der Versicherungstechnik (6 C, 2 SWS)..... 969

B.WIWI-VWL.0001: Mikroökonomik II (6 C, 5 SWS)..... 975

B.WIWI-VWL.0002: Makroökonomik II (6 C, 4 SWS)..... 977

B.WIWI-VWL.0005: Grundlagen der internationalen Wirtschaftsbeziehungen (6 C, 4 SWS)..... 979

B.WIWI-VWL.0006: Wachstum und Entwicklung (6 C, 4 SWS)..... 981

B.WIWI-VWL.0007: Einführung in die Ökonometrie (6 C, 6 SWS)..... 983

B.WIWI-VWL.0008: Geldtheorie und Geldpolitik (6 C, 4 SWS)..... 985

B.WIWI-VWL.0010: Einführung in die Institutionenökonomik (6 C, 2 SWS)..... 987

B.WIWI-VWL.0059: Internationale Finanzmärkte (6 C, 4 SWS)..... 989

M.WIWI-BWL.0134: Panel Data Analysis in Marketing (6 C, 2 SWS)..... 1306

M.WIWI-QMW.0002: Advanced Statistical Inference (Likelihood & Bayes) (6 C, 4 SWS)..... 1307

M.WIWI-QMW.0004: Econometrics I (6 C, 6 SWS)..... 1309

M.WIWI-QMW.0005: Econometrics II (6 C, 4 SWS)..... 1311

M.WIWI-QMW.0009: Introduction to Time Series Analysis (6 C, 4 SWS)..... 1312

M.WIWI-QMW.0012: Multivariate Time Series Analysis (6 C, 4 SWS)..... 1314

M.WIWI-VWL.0001: Advanced Microeconomics (6 C, 4 SWS)..... 1316

M.WIWI-VWL.0041: Panel Data Econometrics (6 C, 4 SWS)..... 1318

M.WIWI-VWL.0092: International Trade (6 C, 4 SWS)..... 1321

M.WIWI-VWL.0128: Deep Determinants of Growth and Development (6 C, 2 SWS)..... 1323

## 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.

B.Mat.0720: Mathematische Anwendersysteme (Grundlagen) (3 C, 2 SWS).....	801
B.Mat.0721: Mathematisch orientiertes Programmieren (6 C, 3 SWS).....	803
B.Mat.0730: Praktikum Wissenschaftliches Rechnen (9 C, 4 SWS).....	805
M.Mat.0731: Advanced practical course in scientific computing (10 C, 4 SWS).....	1031
B.Mat.0740: Stochastisches Praktikum (9 C, 6 SWS).....	807
M.Mat.0741: Advanced practical course in stochastics (10 C, 6 SWS).....	1033
B.Mat.0910: Linux effektiv nutzen (3 C, 2 SWS).....	809
B.Mat.0921: Einführung in TeX/LaTeX und praktische Anwendungen (3 C, 2 SWS).....	811
B.Mat.0922: Mathematics information services and electronic publishing (3 C, 2 SWS).....	813
B.Mat.0923: Scientific Writing (3 C, 2 SWS).....	815
B.Mat.0931: Tutorenttraining (4 C, 2 SWS).....	817
B.Mat.0932: Vermittlung mathematischer Inhalte an ein Fachpublikum (3 C, 2 SWS).....	819
B.Mat.0935: Historische, museumspädagogische und technische Aspekte für den Aufbau, Erhalt und die Nutzung wissenschaftlicher Modellsammlungen (4 C, 2 SWS).....	820
B.Mat.0936: Medienbildung zu mathematischen Objekten und Problemen (4 C, 2 SWS).....	821
B.Mat.0940: Mathematik in der Welt, in der wir leben (3 C, 2 SWS).....	822
B.Mat.0950: Mitgliedschaft in der studentischen oder akademischen Selbstverwaltung (3 C, 1 SWS)...	824
B.Mat.0951: Ehrenamtliches Engagement in einem mathematischen Umfeld (3 C, 1 SWS).....	825
B.Mat.0952: Organisation einer mathematischen Veranstaltung (3 C, 2 SWS).....	826
B.Mat.0970: Betriebspraktikum (8 C).....	827
M.Mat.0971: Internship (10 C).....	1035

## 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.

Die Lehrinheit 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 Modulverzeichnis des Master-Studiengangs „Mathematik“ der Georg-August-Universität Göttingen (Modulnummern M.Mat.4XXX) absolviert werden. Empfohlen werden folgende Module:

B.Mat.1400: Maß- und Wahrscheinlichkeitstheorie (9 C, 6 SWS)..... 828

B.Mat.2100: Partielle Differenzialgleichungen (9 C, 6 SWS).....	830
B.Mat.2110: Funktionalanalysis (9 C, 6 SWS).....	832
B.Mat.2120: Funktionentheorie (9 C, 6 SWS).....	834
B.Mat.2200: Moderne Geometrie (9 C, 6 SWS).....	836
B.Mat.2210: Zahlen und Zahlentheorie (9 C, 6 SWS).....	838
B.Mat.2300: Numerische Analysis (9 C, 6 SWS).....	840
B.Mat.2310: Optimierung (9 C, 6 SWS).....	842

### 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:

B.Mat.1400: Maß- und Wahrscheinlichkeitstheorie (9 C, 6 SWS).....	828
B.Mat.2100: Partielle Differenzialgleichungen (9 C, 6 SWS).....	830
B.Mat.2110: Funktionalanalysis (9 C, 6 SWS).....	832
B.Mat.2120: Funktionentheorie (9 C, 6 SWS).....	834
B.Mat.2200: Moderne Geometrie (9 C, 6 SWS).....	836
B.Mat.2210: Zahlen und Zahlentheorie (9 C, 6 SWS).....	838
B.Mat.2300: Numerische Analysis (9 C, 6 SWS).....	840
B.Mat.2310: Optimierung (9 C, 6 SWS).....	842

## VIII. Methods of examination and glossary

### Methods of examination

As far as in this directory of modules 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 = Studiengangsbeauftragte/r

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module B.Inf.1236: Machine Learning</b>		4 WLH
<b>Learning outcome, core skills:</b> Students <ul style="list-style-type: none"> <li>• learn concepts and techniques of machine learning and understand their advantages and disadvantages compared with alternative approaches</li> <li>• learn techniques of supervised learning for classification and regression</li> <li>• learn techniques of unsupervised learning for density estimation, dimensionality reduction and clustering</li> <li>• implement machine learning algorithms like linear regression, logistic regression, kernel methods, tree-based methods, neural networks, principal component analysis, k-means and Gaussian mixture models</li> <li>• solve practical data science problems using machine learning methods</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Machine Learning (Lecture)</b> Bishop: Pattern recognition and machine learning. <a href="https://cs.ugoe.de/prml">https://cs.ugoe.de/prml</a>		2 WLH
<b>Examination: Written examination (90 minutes)</b> <b>Examination prerequisites:</b> B.Inf.1236.Ex: At least 50% of homework exercises solved and N-1 attempts presented to tutors <b>Examination requirements:</b> Knowledge of the working principles, advantages and disadvantages of the machine learning methods covered in the lecture		6 C
<b>Course: Machine Learning - Exercise (Exercise)</b> <i>Contents:</i> Students present their solutions of the homework exercises to tutors and discuss them with their tutors.		2 WLH
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Knowledge of basic linear algebra and probability English language proficiency at level B2 (CEFR)	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Alexander Ecker	
<b>Course frequency:</b> each summer semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 4	
<b>Maximum number of students:</b> 100		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Inf.1237: Deep Learning</b>		6 C 4 WLH
<b>Learning outcome, core skills:</b> Students <ul style="list-style-type: none"> <li>• learn concepts and techniques of deep learning and understand their advantages and disadvantages compared to alternative approaches</li> <li>• learn to solve practical data science problems using deep learning</li> <li>• implement deep learning techniques like multi-layer perceptrons, convolutional neural networks and other modern deep learning architectures</li> <li>• learn techniques for optimization and regularization of deep neural networks</li> <li>• learn applications of deep neural networks for computer vision tasks such as segmentation and object detection</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Deep Learning for Computer Vision (Lecture)</b> Goodfellow, Bengio, Courville: Deep Learning. <a href="https://www.deeplearningbook.org">https://www.deeplearningbook.org</a> Bishop: Pattern Recognition and Machine Learning. <a href="https://cs.ugoe.de/prml">https://cs.ugoe.de/prml</a>		2 WLH
<b>Examination: Written examination (90 minutes)</b> <b>Examination prerequisites:</b> B.Inf.1237.Ex: At least 50% of homework exercises solved and N-1 attempts presented to tutors <b>Examination requirements:</b> Knowledge of basic deep learning techniques, their advantages and disadvantages and approaches to optimization and regularization. Ability to implement these techniques.		6 C
<b>Course: Deep Learning for Computer Vision - Exercise (Exercise)</b> <i>Contents:</i> Students present their solutions of the homework exercises to tutors and discuss them with their tutors.		2 WLH
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Basic knowledge of linear algebra and probability Completion of B.Inf.1236 Machine Learning or equivalent	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Constantin Pape Prof. Dr. Alexander Ecker	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 5	
<b>Maximum number of students:</b> 100		

<b>Georg-August-Universität Göttingen</b>		5 C
<b>Module B.Inf.1240: Visualization</b>		3 WLH
<b>Learning outcome, core skills:</b> Knowledge of <ul style="list-style-type: none"> <li>• the potentials and limitations of data visualization</li> <li>• the fundamentals of visual perception and cognition and their implications for data visualization. Students can apply these to the design of visualizations and detect manipulative design choices</li> <li>• a broad variety of techniques for visual representation of data, including abstract and high-dimensional data. Students can select appropriate methods on new problems</li> <li>• integration of visualization into the data analysis process, algorithmic generation and interactive methods</li> </ul>		<b>Workload:</b> Attendance time: 42 h Self-study time: 108 h
<b>Course: Visualization</b> (Lecture, Exercise)		3 WLH
<b>Examination: Practical project (2-3 weeks) with presentation and questions during oral exam in groups (approx. 20 minutes per examinee).</b> <b>Examination prerequisites:</b> At least 50% of homework exercises solved. <b>Examination requirements:</b> Knowledge of potentials and limitations of data visualization, fundamentals of visual perception and their implications for good design choices, techniques for visual representation and how to use them.		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Foundations of linear algebra and analysis (e.g. B.Mat.0801 and B.Mat.0802) and programming skills (e.g. B.Inf.1842).	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Bernhard Schmitzer	
<b>Course frequency:</b> once a year	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 3 - 6	
<b>Maximum number of students:</b> 50		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Inf.1241: Computational Optimal Transport</b>		6 C 4 WLH
<b>Learning outcome, core skills:</b> Knowledge of <ul style="list-style-type: none"> <li>the fundamental notions of optimal transport, and its strengths and limitations as a data analysis tool</li> <li>the discrete Kantorovich formulation, its convex duality, and Wasserstein distances</li> <li>classical numerical algorithms, entropic regularization, and their scopes of applicability</li> <li>examples for data analysis applications. Students can transfer these to new potential applications</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Computational Optimal Transport</b> (Lecture, Exercise)		4 WLH
<b>Examination: Written exam (90 minutes) or oral exam (approx. 20 minutes)</b> <b>Examination prerequisites:</b> At least 50% of homework exercises solved. <b>Examination requirements:</b> Knowledge of Kantorovich duality, Wasserstein distances, standard algorithms and implications for data analysis applications.		6 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Foundations of linear algebra and analysis (e.g. B.Mat.0801 and B.Mat.0802) and programming skills (e.g. B.Inf.1842).	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Bernhard Schmitzer	
<b>Course frequency:</b> once a year	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 4 - 6	
<b>Maximum number of students:</b> 50		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0720: Mathematische Anwendersysteme (Grundlagen)</b> <i>English title: Mathematical application software</i>		3 C 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls haben die Studierenden <ul style="list-style-type: none"> <li>• die Grundprinzipien der Programmierung erfasst;</li> <li>• die Befähigung zum sicheren Umgang mit einer Programmiersprache im mathematische Kontext erworben;</li> <li>• Erfahrungen mit elementaren Algorithmen und deren Anwendungen gesammelt.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Kenntnisse über eine Programmiersprache im mathematischen Kontext erworben. Sie <ul style="list-style-type: none"> <li>• haben die Fähigkeit erworben, Algorithmen in einer Programmiersprache umzusetzen;</li> <li>• haben gelernt die Programmiersprache zum Lösen von Algebraischen Problemen zu nutzen (Computeralgebra CAS).</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Blockkurs</b> <i>Inhalte:</i> Blockkurs bestehend aus Vorlesung, Übungen und Praktikum, z.B. "Einführung in Python und Computeralgebra".		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>		3 C
<b>Prüfungsanforderungen:</b> Grundkenntnisse in einer Programmiersprache mit Fokus auf mathematisch orientierte Anwendung und Hintergrund.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0011, B.Mat.0012	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Wintersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> <ul style="list-style-type: none"> <li>• Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik.</li> </ul>		

- Ausschluss: Studierende, die das Modul B.Mat.0721 bereits erfolgreich absolviert haben, dürfen das Modul B.Mat.0720 nicht absolvieren.

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0721: Mathematisch orientiertes Programmieren</b> <i>English title: Mathematics related programming</i>		6 C 3 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Das erfolgreiche Absolvieren des Moduls ermöglicht den Studierenden den sicheren Umgang mit mathematischen Anwendersystemen. Die Studierenden <ul style="list-style-type: none"> <li>• erwerben die Befähigung zum sicheren Umgang mit mathematischen Anwendersystemen,</li> <li>• erfassen die Grundprinzipien der Programmierung,</li> <li>• sammeln Erfahrungen mit elementaren Algorithmen und deren Anwendungen,</li> <li>• verstehen die Grundlagen der Programmierung in einer high-level Programmiersprache,</li> <li>• lernen Kontroll- und Datenstrukturen kennen,</li> <li>• erlernen die Grundzüge des imperativen und funktionalen Programmierens,</li> <li>• setzen Bibliotheken zur Lösung naturwissenschaftlicher Fragestellungen ein,</li> <li>• erlernen verschiedene Methoden der Visualisierung,</li> <li>• beherrschen die Grundtechniken der Projektverwaltung (Versionskontrolle, Arbeiten im Team).</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Techniken für das Lösen mathematisch/physikalischer Problemstellungen mit der Hilfe einer high-level Programmiersprache erlernt.		<b>Arbeitsaufwand:</b> Präsenzzeit: 42 Stunden Selbststudium: 138 Stunden
<b>Lehrveranstaltung: Blockkurs</b> <i>Inhalte:</i> Blockkurs bestehend aus Vorlesung, Übungen und Praktikum, z.B. "Mathematisch orientiertes Programmieren"		2 SWS
<b>Prüfung: Klausur (90 Minuten) oder mündliche Prüfung (ca. 20 min)</b>		6 C
<b>Prüfungsanforderungen:</b> 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.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0011, B.Mat.0012	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b>	<b>Empfohlenes Fachsemester:</b>	

zweimalig	Bachelor: 1 - 6; Master: 1 - 4
<b>Maximale Studierendenzahl:</b> 120	
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0730: Praktikum Wissenschaftliches Rechnen</b> <i>English title: Practical course in scientific computing</i>		9 C 4 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls besitzen die Studierenden praktische Erfahrungen im wissenschaftlichen Rechnen. Sie <ul style="list-style-type: none"> <li>• erstellen größere Programmierprojekte in Einzel- oder Gruppenarbeit;</li> <li>• erwerben und festigen Programmierkenntnisse;</li> <li>• haben Erfahrungen mit grundlegenden Verfahren zur numerischen Lösung von mathematischen Problemen.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>• mathematische Algorithmen und Verfahren in einer Programmiersprache oder einem Anwendersystem zu implementieren;</li> <li>• spezielle numerische Bibliotheken zu nutzen;</li> <li>• komplexe Programmieraufgaben so zu strukturieren, dass sie effizient in Gruppenarbeit bewältigt werden können.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden
<b>Lehrveranstaltung: Praktikum Wissenschaftliches Rechnen</b>		4 SWS
<b>Prüfung: Präsentation (ca. 30 Minuten) oder Hausarbeit (max. 50 Seiten ohne Anhänge)</b> <b>Prüfungsvorleistungen:</b> Regelmäßige Teilnahme im Praktikum		9 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Grundkenntnisse der numerischen Mathematik</li> <li>• gute Programmierkenntnisse</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0721, B.Mat.1300 Kenntnis des objektorientierten Programmierens	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 4 - 6; Master: 1 - 4	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b>		



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

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0740: Stochastisches Praktikum</b> <i>English title: Practical course in stochastics</i>		9 C 6 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> 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 <ul style="list-style-type: none"> <li>• implementieren und interpretieren selbstständig einfache stochastische Problemstellungen in einer entsprechenden Software;</li> <li>• schreiben selbstständig einfache Programme in der entsprechenden Software;</li> <li>• 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.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage <ul style="list-style-type: none"> <li>• eine stochastische Simulations- und Analyse-Software auf konkrete stochastische Problemstellungen anzuwenden und die erhaltenen Resultate fachgerecht zu präsentieren;</li> <li>• statistische Daten und ihre wichtige Eigenschaften adäquat zu visualisieren und interpretieren.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
<b>Lehrveranstaltung: Stochastisches Praktikum</b>		6 SWS
<b>Prüfung: Präsentation (ca. 45 Minuten) mit schriftlicher Ausarbeitung (max. 50 Seiten ohne Anhänge)</b>		9 C
<b>Prüfungsanforderungen:</b> Weiterführende Kenntnisse in Stochastik		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.2410	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 4 - 6; Master: 1 - 4	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

**Bemerkungen:**

Dozent/in: Lehrpersonen des Instituts für Mathematische Stochastik

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0910: Linux effektiv nutzen</b> <i>English title: Effective use of Linux</i>		3 C (Anteil SK: 3 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Das UNIX-Derivat Linux ist mit Abstand das meistgenutzte Betriebssystem, allerdings nicht auf dem Desktop, sondern in Mobiltelefonen, auf Heimgeräten und auf Servern. Auch MAC-Systeme beruhen auf einem UNIX-System. Diese Modul bietet eine Einführung in Grundlagen des Systems und der Netzwerkanbindung von Linux. Der Schwerpunkt liegt in der Nutzung von Linux und der Automation von Aufgaben auf der Commandline. Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über fundierte Grundlagenkenntnisse in folgenden Bereichen: <ul style="list-style-type: none"> <li>• Linux als Einzelsystem;</li> <li>• Linux im Netzwerk;</li> <li>• Automatisierung von Aufgaben mit Shellskripten.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage <ul style="list-style-type: none"> <li>• wesentlichen Abläufe im Linuxsystem zu verstehen;</li> <li>• mit einem Mehrbenutzerbetriebssystem auf der Ebene einfacher Systemverwaltung im Einzel- und im Netzwerkbetrieb umzugehen;</li> <li>• Skripte zur effektiven Aufgabenbewältigung zu erstellen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Vorlesung mit integrierten Übungen</b>		2 SWS
<b>Prüfung: Klausur (90 Minuten), unbenotet</b> <b>Prüfungsvorleistungen:</b> B.Mat.0910.Ue: Erreichen von mindestens 50% der Übungspunkte		3 C
<b>Prüfungsanforderungen:</b> Grundkenntnisse in der Erstellung von Skripten im Einzel- und Netzwerkbetrieb, sicherer Umgang mit und Zuordnung von Begriffen aus einem Mehrbenutzerbetriebssystem im Einzel- und Netzwerkbetrieb.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Sicherer Umgang mit einem Computersystem	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

**Bemerkungen:**

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

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0921: Einführung in TeX/LaTeX und praktische Anwendungen</b> <i>English title: Introduction to TeX/LaTeX with applications</i>		3 C (Anteil SK: 3 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit dem Einsatz von TeX oder LaTeX zur Erstellung von wissenschaftlichen Texten und Vorträgen vertraut. Sie <ul style="list-style-type: none"> <li>• sind vertraut mit ordentlicher Dokumentengliederung;</li> <li>• erstellen Literaturangaben und Querverweise;</li> <li>• erzeugen mathematische Formeln;</li> <li>• erzeugen Grafiken und binden sie ein.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>• einfache Dokumente mit LaTeX zu erstellen;</li> <li>• ansprechende Vortragsfolien mit LaTeX zu erzeugen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Blockkurs</b> <i>Inhalte:</i> Einwöchige Blockveranstaltung mit Praktikum		
<b>Prüfung: Hausarbeit (max. 10 Seiten), unbenotet</b> <b>Prüfungsvorleistungen:</b> Regelmäßige Teilnahme an der Veranstaltung <b>Prüfungsanforderungen:</b> Erstellung eines wissenschaftlichen Portfolios mit TeX/LaTeX und der Folien für eine Präsentation mit Beamer-TeX.		3 C
<b>Prüfungsanforderungen:</b> Sicherer Umgang mit den grundlegenden Funktionen von LaTeX und Beamer-TeX		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Grundkenntnisse im Umgang mit einem Computer.	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

**Bemerkungen:**

Dozent/in: Lehrpersonen des Mathematischen Instituts

<b>Georg-August-Universität Göttingen</b>		3 C (incl. key comp.: 3 C) 2 WLH
<b>Module B.Mat.0922: Mathematics information services and electronic publishing</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> After having successfully completed the module, students are familiar with the basics of mathematics information services and electronic publishing. They <ul style="list-style-type: none"> <li>• work with popular information services in mathematics and with conventional, non-electronic as well as electronic media;</li> <li>• know a broad spectrum of mathematical information sources including classification principles and the role of meta data;</li> <li>• are familiar with current development in the area of electronic publishing in the subject mathematics.</li> </ul> <b>Core skills:</b> After successful completion of the module students have acquired subject-specific information competencies. They <ul style="list-style-type: none"> <li>• have suitable research skills;</li> <li>• are familiar with different information and specific publication services.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Lecture course (Lecture)</b> <i>Contents:</i> Lecture course with project report		
<b>Examination: Written examination (90 minutes), not graded</b> <b>Examination prerequisites:</b> Regular participation in the course		3 C
<b>Examination requirements:</b> Application of the acquired skills in individual projects in the area of mathematical information services and electronic publishing		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> each summer semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b>		



**Instructors:** Lecturers at the Mathematical Institute

<p><b>Georg-August-Universität Göttingen</b>  <b>Module B.Mat.0923: Scientific Writing</b></p>	<p>3 C (incl. key comp.: 3 C)                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b>                  After having successfully completed the module, students are familiar with the basics of scientific writing.</p> <p>Objectives:</p> <ul style="list-style-type: none"> <li>• How to start; motivation for writing a paper (thesis, term paper, seminar presentation, conference talk); choice of language (German/English/?); when to start; support resources.</li> <li>• Different text types in the professional career, e.g. motivation letter, research report, technical report, proposal etc.</li> <li>• Plagiarism; different types of plagiarism, unintentional and intentional plagiarism; how to avoid and recognise plagiarism? How to avoid being accused of plagiarism?</li> <li>• Planning and execution, structure, overall style of language, clear and concise writing, writing problems and how to avoid them, cultural sensitivity, cultural transferability.</li> <li>• Discussion; purpose, content, tense, structure; introducing tense, voice and mood; introducing modular writing and why it helps.</li> <li>• Methods; purpose, content (Bishop report implications), tense, structure.</li> <li>• Results; purpose, content, tense, structure; what goes in figures, images and tables; effective placing and citation of figures, images, tables; warning on image manipulation.</li> <li>• Introduction; purpose, content, tense, structure.</li> <li>• Title, abstract, key words, search engine optimization, list of references, acknowledgements.</li> <li>• Optionally, choosing a journal, text matching, predatory &amp; trick journals, your audience, factors affecting choice, scope, impact factors, open access.</li> <li>• Optionally, ethics of publication, COPE, Vancouver rules and other bodies, authorship, author order, contributorship statements, coauthors, corresponding authors, chaperones, grievance procedures.</li> </ul> <p><b>Core skills:</b>                  After successful completion of the module students have acquired subject-specific competencies in scientific writing. They</p> <ul style="list-style-type: none"> <li>• have suitable research skills;</li> <li>• are familiar with how to find and discuss a topic academically and using academic terms and methodology.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Lecture course</b> (Lecture)  <i>Contents:</i>                  Lecture course with project report</p>	<p>2 WLH</p>

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<b>Examination: Term Paper (max. 15 pages), not graded</b>	3 C
<b>Examination requirements:</b> Application of the acquired skills in individual projects in the area of mathematical information services and electronic publishing	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructors:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0931: Tutorentraining</b> <i>English title: Coaching of teaching assistants</i>		4 C (Anteil SK: 4 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit theoretischen und praktischen Fragestellungen der Vermittlung mathematischen Wissens vertraut. Sie werden befähigt, <ul style="list-style-type: none"> <li>• mathematische Inhalte an Studierende im ersten Semester zu vermitteln;</li> <li>• eine heterogene Übungsgruppe zu leiten.</li> <li>• verschiedene Lehrmethoden und Visualisierungstechniken einzusetzen;</li> <li>• souverän aufzutreten.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>• Rhetorik- und Präsentationstechniken einzusetzen;</li> <li>• Teamkompetenzen (insb. Motivationsfähigkeit und sicherer Umgang mit Konfliktsituationen) einzusetzen;</li> <li>• Methoden des Zeitmanagements zu verwenden;</li> <li>• interkulturelle Kompetenzen, insbesondere interkulturelle Kommunikationswege einzusetzen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 92 Stunden
<b>Lehrveranstaltung: Integratives Projekt</b> <i>Inhalte:</i> Neben dem Leiten einer Übungsgruppe während des gesamten Semesters oder einer Blockveranstaltung beinhaltet das Projekt ein Vorbereitungsseminar und ein Abschlussseminar sowie begleitende Kurzveranstaltungen.		
<b>Prüfung: Präsentation [Übungsstunde] (ca. 45 Minuten) und schriftliche Ausarbeitung (max. 5 Seiten), unbenotet</b> <b>Prüfungsvorleistungen:</b> Teilnahme an der Veranstaltung		4 C
<b>Prüfungsanforderungen:</b> Nachweis des Erreichens der Lernziele und Erwerbs der Kompetenzen durch Umsetzung in einer Übungsstunde		
<b>Zugangsvoraussetzungen:</b> Übertragung der Leitung einer Übungsgruppe zu einer Lehrveranstaltung der Fakultät für Mathematik und Informatik im gleichen Semester	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b>	<b>Dauer:</b>	

jedes Wintersemester	1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 3 - 6; Master: 1 - 4; Promotion: 1 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen des Mathematischen Instituts	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0932: Vermittlung mathematischer Inhalte an ein Fachpublikum</b> <i>English title: Communicating mathematical topics to a professional audience</i>		3 C (Anteil SK: 3 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit theoretischen und praktischen Grundlagen der Vermittlung mathematischen Wissens vertraut. Sie <ul style="list-style-type: none"> <li>• schätzen das Niveau der Zielgruppe einer mathematischen Darbietung ein;</li> <li>• strukturieren Präsentationen gut;</li> <li>• beherrschen sicher stilistische und technische Aspekte der Darbietung;</li> <li>• wählen adäquate Hilfsmittel (z.B. zur Visualisierung);</li> <li>• steuern die Diskussion mit dem Publikum.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über je nach Veranstaltung verschiedene Kommunikations- und Vermittlungskompetenzen sowie ggf. Fremdsprachenkompetenzen.		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Veranstaltung mit theoretischem und praktischem Anteil, kann ggf. als Blockveranstaltung angeboten werden oder als Teil eines mathematischen Seminars. (Seminar)</b>		
<b>Prüfung: Präsentation (45 Minuten), unbenotet</b> <b>Prüfungsvorleistungen:</b> Teilnahme an der Veranstaltung		3 C
<b>Prüfungsanforderungen:</b> Nachweis des Erreichens der Lernziele durch Anfertigen einer Darbietung zur Vermittlung mathematischer Inhalte (Format der Darbietung je nach Veranstaltung)		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> keine Angabe	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 3 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen der Lehrinheit Mathematik		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0935: Historische, museumspädagogische und technische Aspekte für den Aufbau, Erhalt und die Nutzung wissenschaftlicher Modellsammlungen</b> <i>English title: Historical, museum-related, and technical aspects of the building-up, the maintenance and the use of scientific collections</i>		4 C (Anteil SK: 4 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über Kenntnisse des Planens und Gestaltens von Mathematikunterricht und mathematikdidaktischen Forschungsprojekten  <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls nutzen die Studierenden Kenntnisse der mathematischen Wissensvermittlung. Sie <ul style="list-style-type: none"> <li>• ordnen wissenschaftliche Modellsammlungen in ihren historischen Kontext ein,</li> <li>• nutzen museumspädagogische Ansätze für die Vermittlung mit Hilfe von Objekten,</li> <li>• kennen Beispiele für Techniken, die für den Aufbau und Erhalt von Objekten in Modellsammlungen erforderlich sind.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 92 Stunden
<b>Lehrveranstaltung: Seminar</b>		2 SWS
<b>Prüfung: Portfolio (max. 5000 Zeichen), unbenotet</b>		4 C
<b>Prüfungsanforderungen:</b> Erarbeitung historischer, museumspädagogischer und technischer Aspekte eines Modells oder mehrerer Modelle in Kontexten von Sammlungen.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> keine Angabe	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Master: 1 - 4	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen des Mathematischen Instituts		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0936: Medienbildung zu mathematischen Objekten und Problemen</b> <i>English title: Media education for mathematical objects and problems</i>		4 C (Anteil SK: 4 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über Kenntnisse des Medienunterstützten Lehrens und Lernens zu mathematischen Objekten und Problemen. <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls ordnen die Studierenden wissenschaftliche Modellsammlungen in ihren historischen Kontext ein. Sie <ul style="list-style-type: none"> <li>• nutzen Kenntnisse der Medienbildung zur mathematischen Wissensvermittlung,</li> <li>• vergleichen unterschiedliche Designs für die Illustration mathematischer Objekte und Probleme,</li> <li>• implementieren beispielhaft unterschiedliche medientechnische Realisierungen mathematischer</li> <li>• Objekte.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 92 Stunden
<b>Lehrveranstaltung: Seminar</b>		2 SWS
<b>Prüfung: Portfolio (max. 5000 Zeichen), unbenotet</b>		4 C
<b>Prüfungsanforderungen:</b> Erarbeitung medienbezogener Aspekte eines Modells oder mehrerer Modelle in Kontexten von Sammlungen.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> keine Angabe	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Master: 1 - 4	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> <b>Dozent/in:</b> Lehrpersonen des Mathematischen Instituts		



<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0940: Mathematik in der Welt, in der wir leben</b> <i>English title: The mathematical nature of the world we are living in</i>		3 C (Anteil SK: 3 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> 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 <ul style="list-style-type: none"> <li>• entwickeln ein stärkeres Bewusstsein für die Rolle der Mathematik in anderen Fachdisziplinen;</li> <li>• erwerben ein tieferes Verständnis für die Bedeutung der Mathematik für den (technologischen) Fortschritt;</li> <li>• erkennen die Bedeutung der Mathematik für das Verständnis von Vorgängen und Erscheinungen in der Natur;</li> <li>• verstehen die Rolle der Mathematik in der Gesellschaft.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über verschiedene Kompetenzen, je nach Ausgestaltung der Lehrveranstaltung haben sie <ul style="list-style-type: none"> <li>• ihre Befähigung zum Logischen Denken ausgebaut;</li> <li>• das mathematische Interpretieren von Observationen und Daten in einem außermathematischem Kontext erlernt;</li> <li>• die Transferfähigkeit von abstraktem Wissen auf reelle Situationen erworben;</li> <li>• ihre Methodenkompetenz im mathematischen Bereich gestärkt.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Vorlesung oder Seminar</b>		
<b>Prüfung: Klausur (90 Minuten) oder Hausarbeit (max. 10 Seiten), unbenotet</b>		3 C
<b>Prüfungsanforderungen:</b> Nachweis des Erreichens der Lernziele durch Anwendung auf ausgewählte Problemstellungen		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jährlich	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

**Bemerkungen:**

Dozent/in: Lehrpersonen der Lehrinheit Mathematik

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0950: Mitgliedschaft in der studentischen oder akademischen Selbstverwaltung</b> <i>English title: Membership in the student or academic self-government</i>		3 C (Anteil SK: 3 C) 1 SWS
<b>Lernziele/Kompetenzen:</b> 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.	<b>Arbeitsaufwand:</b> Präsenzzeit: 14 Stunden Selbststudium: 76 Stunden	
<b>Lehrveranstaltung: Gremienveranstaltung</b>		
<b>Prüfung: Hausarbeit (max. 5 Seiten), unbenotet</b>		3 C
<b>Prüfungsanforderungen:</b> Die Studierenden erbringen den Nachweis der Befähigung, dass sie Erfahrungen aus der Praxis mit theoretischen Wissen verknüpfen und Methoden der Reflektion anwenden können.		
<b>Zugangsvoraussetzungen:</b> Mitgliedschaft in mindestens einem der folgenden Gremien: <ol style="list-style-type: none"> <li>1. Fakultätsrat der Fakultät für Mathematik und Informatik oder eine seiner Kommissionen</li> <li>2. Senat der Universität oder einer seiner Kommissionen</li> <li>3. Vorstand des Studentenwerks</li> </ol>	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Dozent/in: Studiendekan/in Mathematik oder Studienreferent/in Mathematik		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0951: Ehrenamtliches Engagement in einem mathematischen Umfeld</b> <i>English title: Civic engagement in a mathematical environment</i>		3 C (Anteil SK: 3 C) 1 SWS
<b>Lernziele/Kompetenzen:</b> 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: <ul style="list-style-type: none"> <li>• Moderationstechniken,</li> <li>• Gesprächsführung</li> <li>• Entscheidungs- und Konfliktlösungsverhalten in Gruppen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 14 Stunden Selbststudium: 76 Stunden
<b>Lehrveranstaltung: Projektarbeit</b>		
<b>Prüfung: Portfolio (max. 5 Seiten), unbenotet</b>		3 C
<b>Prüfungsanforderungen:</b> Die Studierenden erbringen den Nachweis der Befähigung, dass sie Erfahrungen aus der Praxis mit theoretischen Wissen verknüpfen und Methoden der Reflektion anwenden können.		
<b>Zugangsvoraussetzungen:</b> Ehrenamtliche Tätigkeit ohne Entgelt oder Aufwandsentschädigung, z.B. <ol style="list-style-type: none"> <li>1. bei der Durchführung der Mathematik-Olympiade oder dem Bundeswettbewerb Mathematik</li> <li>2. Nachhilfe im Rahmen von sozialen Projekten</li> <li>3. Mathematisches Korrespondenz-Zirkel</li> <li>4. MatheCamp</li> </ol>	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Dozent/in: Studiendekan/in Mathematik oder Studienreferent/in Mathematik		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0952: Organisation einer mathematischen Veranstaltung</b> <i>English title: Event management in mathematics</i>		3 C (Anteil SK: 3 C) 2 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> 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.  <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls verfügen die Studierenden über verschiedene Kompetenzen, je nach Ausgestaltung des Veranstaltungsprojekts erwerben sie <ul style="list-style-type: none"> <li>• Organisations- und Managementkompetenzen;</li> <li>• Kompetenzen im Informations- und Zeitmanagement;</li> <li>• Teamkompetenz.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Integratives Projekt</b> <i>Inhalte:</i>  <i>Angebotshäufigkeit:</i> jährlich		
<b>Prüfung: Projektpräsentation (ca. 20 Minuten) oder Hausarbeit (max. 5 Seiten), unbenotet</b>		3 C
<b>Prüfungsanforderungen:</b> Nachweis der Kompetenzen und Fähigkeiten durch einen abgegrenzten, aktiven Beitrag zu einem Veranstaltungsprojekt.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> keine Angabe	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 1 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen der Lehrinheit Mathematik		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.0970: Betriebspraktikum</b> <i>English title: Internship</i>		8 C (Anteil SK: 8 C)
<b>Lernziele/Kompetenzen:</b> 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 0 Stunden Selbststudium: 240 Stunden
<b>Lehrveranstaltung: Prüfungskolloquium</b> (Kolloquium)		
<b>Prüfung: Präsentation (ca. 20 Minuten) mit schriftlicher Ausarbeitung (max. 10 Seiten), unbenotet</b> <b>Prüfungsvorleistungen:</b> Bescheinigung über die erfolgreiche Erfüllung der gestellten Aufgaben gemäß Praktikumsplan		8 C
<b>Prüfungsanforderungen:</b> Erfolgreiche Bearbeitung der gestellten Aufgaben gemäß zwischen dem oder der Studierenden, der Lehrperson und dem Betrieb zu vereinbarendem Praktikumsplan		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Studiendekan*in	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 4 - 6; Master: 1 - 4; Promotion: 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen der Lehrinheit Mathematik		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.1400: Maß- und Wahrscheinlichkeitstheorie</b> <i>English title: Measure and probability theory</i>	9 C 6 SWS
<p><b>Lernziele/Kompetenzen:</b></p> <p><b>Lernziele:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• modellieren diskrete Wahrscheinlichkeitsräume, beherrschen die damit verbundene Kombinatorik sowie den Einsatz von Unabhängigkeit und bedingten Wahrscheinlichkeiten;</li> <li>• kennen die wichtigsten Verteilungen von Zufallsvariablen;</li> <li>• verstehen grundlegende Eigenschaften sowie Existenz und Eindeutigkeitsaussagen von Maßen;</li> <li>• gehen sicher mit allgemeinen Maß-Integralen um, insbesondere mit dem Lebesgue-Integral;</li> <li>• kennen sich mit <math>L_p</math>-Räumen und Produkträumen aus;</li> <li>• formulieren wahrscheinlichkeitstheoretische Aussagen mit Wahrscheinlichkeitsräumen, Wahrscheinlichkeitsmaßen und Zufallsvariablen;</li> <li>• rechnen und modellieren mit stetigen und mehrdimensionalen Verteilungen;</li> <li>• beschreiben Wahrscheinlichkeitsmaße mit Hilfe von Verteilungsfunktionen bzw. Dichten;</li> <li>• verstehen und nutzen das Konzept der Unabhängigkeit;</li> <li>• berechnen Erwartungswerte von Funktionen von Zufallsvariablen;</li> <li>• verstehen die verschiedenen stochastischen Konvergenzbegriffe und ihre Beziehungen;</li> <li>• kennen charakteristische Funktionen und deren Anwendungen;</li> <li>• besitzen Grundkenntnisse über bedingte Wahrscheinlichkeiten und bedingte Erwartungswerte;</li> <li>• verwenden das schwache Gesetz der großen Zahlen und den zentralen Grenzwertsatz;</li> <li>• kennen einfache stochastische Prozesse wie z.B. Markov-Ketten.</li> </ul> <p><b>Kompetenzen:</b></p> <p>Nach erfolgreichem Absolvieren des Moduls haben die Studierenden grundlegende Kompetenzen im Schwerpunkt "Mathematische Stochastik" erworben. Sie sind in der Lage,</p> <ul style="list-style-type: none"> <li>• Maßräume und Maß-Integrale anzuwenden;</li> <li>• stochastische Denkweisen einzusetzen und einfache stochastische Modelle zu formulieren;</li> <li>• stochastische Modelle mathematisch zu analysieren;</li> <li>• die wichtigsten Verteilungen zu verstehen und anzuwenden;</li> <li>• stochastische Abschätzungen mit Hilfe von Wahrscheinlichkeitsgesetzen</li> </ul>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 84 Stunden</p> <p>Selbststudium: 186 Stunden</p>

durchzuführen; • grundlegende Grenzwertsätze der Wahrscheinlichkeitstheorie zu verwenden.	
<b>Lehrveranstaltung: Maß- und Wahrscheinlichkeitstheorie</b> (Vorlesung)	4 SWS
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.1400.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C
<b>Lehrveranstaltung: Maß- und Wahrscheinlichkeitstheorie - Übung</b> (Übung)	2 SWS
<b>Prüfungsanforderungen:</b> Nachweis von Grundkenntnissen in diskreter Stochastik sowie Maß- und Wahrscheinlichkeitstheorie	
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r
<b>Angebotshäufigkeit:</b> jedes Wintersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 5
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen des Instituts für Mathematische Stochastik	



<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2100: Partielle Differenzialgleichungen</b> <i>English title: Partial differential equations</i>		9 C 6 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit grundlegenden Typen von Differenzialgleichungen und Eigenschaften ihrer Lösungen vertraut. Sie <ul style="list-style-type: none"> <li>• beschreiben grundlegende Eigenschaften von Lösungen der Laplace-, Wärmeleitungs- und Wellengleichung und zugehöriger Rand- bzw. Anfangs-Randwertprobleme;</li> <li>• sind mit grundlegenden Eigenschaften von Fourier-Transformation und Sobolev-Räumen auf beschränkten und unbeschränkten Gebieten vertraut;</li> <li>• analysieren die Lösbarkeit von Randwertproblemen für elliptische Differenzialgleichungen mit variablen Koeffizienten;</li> <li>• analysieren die Regularität von Lösungen elliptischer Randwertprobleme im Inneren und am Rand.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>• den Typ einer partiellen Differenzialgleichung zu erkennen und auf qualitative Eigenschaften ihrer Lösungen zu schließen;</li> <li>• mathematisch relevante Fragestellungen zu partiellen Differenzialgleichungen zu erkennen;</li> <li>• den Einfluss von Randbedingungen und Funktionenräumen auf Existenz, Eindeutigkeit und Stabilität von Lösungen zu beurteilen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
<b>Lehrveranstaltung: Partielle Differenzialgleichungen</b> (Vorlesung)		4 SWS
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2100.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen		9 C
<b>Lehrveranstaltung: Partielle Differenzialgleichungen - Übung</b> (Übung)		2 SWS
<b>Prüfungsanforderungen:</b> Nachweis der Grundkenntnisse über partielle Differenzialgleichungen		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r	
<b>Angebotshäufigkeit:</b> zweijährig jeweils im Wintersemester	<b>Dauer:</b> 1 Semester	

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<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

**Bemerkungen:**

- Dozent/in: Lehrpersonen des Mathematischen Instituts oder des Instituts für Numerische und Angewandte Mathematik
- Ausschlüsse: Dieses Modul darf nicht in dem Studiengang "Master of Education", Fach Mathematik, eingebracht werden, wenn im Bachelor-Studium bereits eines der nachstehenden Module eingebracht wurde:
  - B.Mat.1100 „Analysis auf Mannigfaltigkeiten“
  - B.Mat.2110 „Funktionalanalysis“
  - B.Mat.2120 „Funktionentheorie“
  - B.Mat.2100 „Partielle Differenzialgleichungen“
  - B.Mat.0030 „Gewöhnliche Differenzialgleichungen“

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2110: Funktionalanalysis</b> <i>English title: Functional analysis</i>	9 C 6 SWS
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<p><b>Lernziele/Kompetenzen:</b></p> <p><b>Lernziele:</b></p> <p>Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit funktionalanalytischer Denkweise und den zentralen Resultaten aus diesem Gebiet vertraut. Sie</p> <ul style="list-style-type: none"> <li>gehen sicher mit den gängigsten Beispielen von Funktionen- und Folgenräumen wie <math>L_p</math>, <math>l_p</math> und Räumen stetiger Funktionen um und analysieren deren funktionalanalytische Eigenschaften;</li> <li>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;</li> <li>argumentieren mit schwachen Konvergenzbegriffen und den grundlegenden Eigenschaften von Dual- und Bidualräumen;</li> <li>erkennen Kompaktheit von Operatoren und analysieren die Lösbarkeit linearer Operatorgleichungen mit Hilfe der Riesz-Fredholm-Theorie;</li> <li>sind mit grundlegenden Begriffen der Spektraltheorie und dem Spektralsatz für beschränkte, selbstadjungierte Operatoren vertraut.</li> </ul> <p><b>Kompetenzen:</b></p> <p>Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage,</p> <ul style="list-style-type: none"> <li>in unendlich-dimensionalen Räumen geometrisch zu argumentieren;</li> <li>Aufgabenstellungen in funktionalanalytischer Sprache zu formulieren und zu analysieren;</li> <li>die Relevanz funktionalanalytischer Eigenschaften wie der Wahl eines passenden Funktionenraums, Vollständigkeit, Beschränktheit oder Kompaktheit zu erkennen und zu beschreiben.</li> </ul>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 84 Stunden</p> <p>Selbststudium: 186 Stunden</p>
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<b>Lehrveranstaltung: Funktionalanalysis</b> (Vorlesung)	4 SWS
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<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2110.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C
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<b>Lehrveranstaltung: Funktionalanalysis - Übung</b> (Übung)	2 SWS
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<b>Prüfungsanforderungen:</b> Nachweis der Grundkenntnisse über Funktionalanalysis	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022
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<b>Sprache:</b>	<b>Modulverantwortliche[r]:</b>
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Englisch, Deutsch	Studiengangsbeauftragte/r
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> <ul style="list-style-type: none"> <li>• Dozent/in: Lehrpersonen des Mathematischen Instituts oder des Instituts für Numerische und Angewandte Mathematik</li> <li>• Ausschlüsse: Dieses Modul darf nicht in dem Studiengang "Master of Education", Fach Mathematik, eingebracht werden, wenn im Bachelor-Studium bereits eines der nachstehenden Module eingebracht wurde: <ul style="list-style-type: none"> <li>- B.Mat.1100 „Analysis auf Mannigfaltigkeiten“</li> <li>- B.Mat.2110 „Funktionalanalysis“</li> <li>- B.Mat.2120 „Funktionentheorie“</li> <li>- B.Mat.2100 „Partielle Differenzialgleichungen“</li> <li>- B.Mat.0030 „Gewöhnliche Differenzialgleichungen“</li> </ul> </li> </ul>	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2120: Funktionentheorie</b> <i>English title: Complex analysis</i>		9 C 6 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der komplexen Analysis vertraut. Sie <ul style="list-style-type: none"> <li>gehen sicher mit dem Holomorphiebegriff um und kennen gängige Beispiele von holomorphen Funktionen;</li> <li>beherrschen insbesondere die verschiedenen Definitionen für Holomorphie und erkennen deren Äquivalenz;</li> <li>verstehen den Cauchyschen Intergralsatz und den Residuensatz und wenden diese Sätze innerhalb der Funktionentheorie an;</li> <li>erarbeiten weitere ausgewählte Themen der Funktionentheorie;</li> <li>erlernen und vertiefen funktionentheoretische Herangehensweisen an mathematische Problemstellungen an Hand ausgewählter Beispiele.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>sicher mit grundlegenden Methoden und Grundbegriffen aus der Funktionentheorie umzugehen;</li> <li>auf Basis funktionentheoretischer Denkweisen und Beweistechniken zu argumentieren;</li> <li>sich in verschiedene Fragestellungen im Bereich "Funktionentheorie" einzuarbeiten;</li> <li>funktionentheoretische Methoden auf weiterführende Themen aus der Funktionentheorie und verwandten Gebieten anzuwenden.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
<b>Lehrveranstaltung: Funktionentheorie (Vorlesung)</b>		4 SWS
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2120.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen		9 C
<b>Lehrveranstaltung: Funktionentheorie - Übung (Übung)</b>		2 SWS
<b>Prüfungsanforderungen:</b> Nachweis der Grundkenntnisse in Funktionentheorie		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r	
<b>Angebotshäufigkeit:</b>	<b>Dauer:</b>	

jedes Sommersemester	1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> <ul style="list-style-type: none"><li>• Dozent/in: Lehrpersonen des Mathematischen Instituts</li><li>• Ausschlüsse: Dieses Modul darf nicht in dem Studiengang "Master of Education", Fach Mathematik, eingebracht werden, wenn im Bachelor-Studium bereits eines der nachstehenden Module eingebracht wurde:<ul style="list-style-type: none"><li>- B.Mat.1100 „Analysis auf Mannigfaltigkeiten“</li><li>- B.Mat.2110 „Funktionalanalysis“</li><li>- B.Mat.2120 „Funktionentheorie“</li><li>- B.Mat.2100 „Partielle Differenzialgleichungen“</li><li>- B.Mat.0030 „Gewöhnliche Differenzialgleichungen“</li></ul></li></ul>	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2200: Moderne Geometrie</b> <i>English title: Modern geometry</i>		9 C 6 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> 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 <ul style="list-style-type: none"> <li>• kennen die Grundlagen der Differenzialgeometrie von Kurven und Flächen;</li> <li>• sind mit den inneren Eigenschaften von Flächen vertraut;</li> <li>• lernen einfache globale Ergebnisse kennen;</li> </ul> oder sie <ul style="list-style-type: none"> <li>• kennen grundlegende Konzepte der algebraischen Geometrie in wichtigen Beispielen;</li> <li>• sind mit der Formulierung geometrischer Fragen in der Sprache der Algebra vertraut;</li> <li>• arbeiten mit zentralen Begriffen und Ergebnissen der kommutativen Algebra.</li> </ul> <b>Kompetenzen:</b> 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, <ul style="list-style-type: none"> <li>• geometrische Fragestellungen mit Konzepten der Differenzialgeometrie oder der algebraischen Geometrie zu präzisieren;</li> <li>• Probleme anhand von Ergebnissen der Differenzialgeometrie oder der algebraischen Geometrie zu lösen;</li> <li>• mit Fragestellungen und Anwendungen des jeweiligen Gebiets umzugehen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
<b>Lehrveranstaltung: Vorlesung</b> (Vorlesung)		4 SWS
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2200.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen		9 C
<b>Lehrveranstaltung: Übung</b> <i>Angebotshäufigkeit: jedes Wintersemester</i>		2 SWS
<b>Prüfungsanforderungen:</b> Nachweis der Grundkenntnisse über Geometrie		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022	

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<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen des Mathematischen Instituts	



<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2210: Zahlen und Zahlentheorie</b> <i>English title: Numbers and number theory</i>	9 C 6 SWS
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<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der elementaren Zahlentheorie vertraut. Sie <ul style="list-style-type: none"> <li>• erwerben grundlegende Kenntnisse über Zahlentheorie;</li> <li>• sind insbesondere mit Teilbarkeit, Kongruenzen, arithmetischen Funktionen, Reziprozitätsgesetz, elementaren diophantischen Gleichungen vertraut;</li> <li>• kennen die elementare Theorie p-adischer Zahlen;</li> <li>• sind mit weiteren ausgewählten Themen der Zahlentheorie vertraut.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>• elementare zahlentheoretische Denkweisen und Beweistechniken zu beherrschen;</li> <li>• mit Grundbegriffen und grundlegenden Methoden der Zahlentheorie zu argumentieren;</li> <li>• mit Begriffen und Methoden aus weiterführenden Themen der Zahlentheorie zu arbeiten.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
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<b>Lehrveranstaltung: Zahlen und Zahlentheorie (Vorlesung)</b>	4 SWS
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<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2210.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen	9 C
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<b>Lehrveranstaltung: Zahlen und Zahlentheorie - Übung (Übung)</b>	2 SWS
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<b>Prüfungsanforderungen:</b> Nachweis der Grundkenntnisse der Zahlentheorie	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Bemerkungen:</b>
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- Dozent/in: Lehrpersonen des Mathematischen Instituts
- Ausschlüsse: Dieses Modul darf nicht in dem Studiengang "Master of Education", Fach Mathematik, eingebracht werden, wenn im Bachelor-Studium bereits eines der nachstehenden Module eingebracht wurde:
  - B.Mat.1200 „Algebra“
  - B.Mat.2210 „Zahlen und Zahlentheorie“
  - B.Mat.2220 „Diskrete Mathematik“

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2300: Numerische Analysis</b> <i>English title: Numerical analysis</i>		9 C 6 SWS
<b>Lernziele/Kompetenzen:</b> Lernziele: Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit weiterführenden Begriffen und Methoden im Schwerpunkt "Numerische und angewandte Mathematik" vertraut. Sie <ul style="list-style-type: none"> <li>• interpolieren vorgegebene Stützpunkte mit Hilfe von Polynomen, trigonometrischen Polynomen und Splines;</li> <li>• integrieren Funktionen numerisch mit Hilfe von Newton-Cotes Formeln, Gauß-Quadratur und Romberg-Quadratur;</li> <li>• modellieren Evolutionsprobleme mit Anfangswertaufgaben für Systeme von gewöhnlichen Differenzialgleichungen, lösen diese numerisch mit Runge-Kutta-Verfahren und analysieren deren Konvergenz;</li> <li>• erkennen die Steifheit von gewöhnlichen Differenzialgleichungen und lösen entsprechende Anfangswertprobleme mit impliziten Runge-Kutta-Verfahren;</li> <li>• 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.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage <ul style="list-style-type: none"> <li>• Algorithmen zur Lösung mathematischer Probleme zu entwickeln und</li> <li>• deren Stabilität, Fehlerverhalten und Komplexität abzuschätzen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
<b>Lehrveranstaltung: Numerische Mathematik II - Übung</b>		2 SWS
<b>Lehrveranstaltung: Numerische Mathematik II</b>		4 SWS
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2300.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen		9 C
<b>Prüfungsanforderungen:</b> Nachweis weiterführender Kenntnisse in numerischer Mathematik		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.1300	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b>	<b>Empfohlenes Fachsemester:</b>	

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zweimalig	4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> Dozent/in: Lehrpersonen des Instituts für Numerische und Angewandte Mathematik	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Mat.2310: Optimierung</b> <i>English title: Optimisation</i>		9 C 6 SWS
<b>Lernziele/Kompetenzen:</b> <b>Lernziele:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden mit Grundbegriffen und Methoden der Optimierung vertraut. Sie <ul style="list-style-type: none"> <li>• lösen lineare Optimierungsprobleme mit dem Simplex-Verfahren und sind mit der Dualitätstheorie der linearen Optimierung vertraut;</li> <li>• beurteilen Konvergenzeigenschaften und Rechenaufwand von grundlegenden Verfahren für unrestringierte Optimierungsprobleme wie Gradienten- und (Quasi-)Newton-Verfahren;</li> <li>• kennen Lösungsverfahren für nichtlineare, restringierte Optimierungsprobleme und gehen sicher mit den KKT-Bedingungen um;</li> <li>• modellieren Netzwerkflussprobleme und andere Aufgaben als ganzzahlige Optimierungsprobleme und erkennen totale Unimodularität.</li> </ul> <b>Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sind die Studierenden in der Lage, <ul style="list-style-type: none"> <li>• Optimierungsaufgaben in der Praxis zu erkennen und als mathematische Programme zu modellieren sowie</li> <li>• geeignete Lösungsverfahren zu erkennen und zu entwickeln.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 186 Stunden
<b>Lehrveranstaltung: Übungen</b> <i>Angebotshäufigkeit: jedes Wintersemester</i>		2 SWS
<b>Lehrveranstaltung: Vorlesung</b> (Vorlesung)		4 SWS
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> B.Mat.2310.Ue: Erreichen von mindestens 50% der Übungspunkte und zweimaliges Vorrechnen von Lösungen in den Übungen		9 C
<b>Prüfungsanforderungen:</b> Nachweis der Grundkenntnisse der Optimierung		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.Mat.0021, B.Mat.0022	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Studiengangsbeauftragte/r	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 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.

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module B.Mat.3041: Overview on non-life insurance mathematics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> After completion of the module students are familiar with basic notions and methods of non-life insurance mathematics. They <ul style="list-style-type: none"> <li>• are familiar with basic definitions and terms within non-life insurance mathematics;</li> <li>• understand central aspects of risk theory;</li> <li>• know substantial pricing and reserving methods;</li> <li>• estimate ruin probabilities.</li> </ul> <b>Core skills:</b> After successful completion of the module students have acquired basic competencies within non-life insurance. They are able to <ul style="list-style-type: none"> <li>• apply a basic inventory of solving approaches;</li> <li>• analyse and develop pricing models which mathematically are state of the art;</li> <li>• evaluate and quantify fundamental risks.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Lecture course</b> (Lecture)		2 WLH
<b>Examination: Written examination (120 minutes)</b>		3 C
<b>Examination requirements:</b> Basic knowledge on non-life insurance mathematics		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 4 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		3 C
<b>Module B.Mat.3042: Overview on life insurance mathematics</b>		2 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> After successfully completing this module students are familiar with basic notions and methods of life insurance mathematics. In particular they <ul style="list-style-type: none"> <li>• master fundamental terms and notions of life insurance mathematics;</li> <li>• know about risk theory and risk management;</li> <li>• know substantial pricing and reserving methods, in particular in health insurance;</li> <li>• know about legal requirements of life, health and pension insurance in Germany.</li> </ul> <b>Core skills:</b> After successful completion of the module students have acquired basic competencies within life insurance mathematics. The student should be able to <ul style="list-style-type: none"> <li>• apply a basic inventory of solving approaches;</li> <li>• calculate premiums and provisions in life, health and pension insurance;</li> <li>• evaluate and quantify fundamental risks.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Lecture course (Lecture)</b>		2 WLH
<b>Examination: Written examination (120 minutes)</b>		3 C
<b>Examination requirements:</b> Basic knowledge on life insurance mathematics		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 4 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers of the Institute of Mathematical Stochastics		



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3043: Non-life insurance mathematics</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p>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:</p> <ul style="list-style-type: none"> <li>• determining appropriate insurance premiums;</li> <li>• calculate adequate loss reserves;</li> <li>• determine how to allocate risk between policyholder and insurer resp. insurer and reinsurers.</li> </ul> <p>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. <a href="http://www.aktuar.de">www.aktuar.de</a>). To this end, the course is designed in view of current legislative and regulatory provisions of the Federal Republic of Germany.</p> <p><b>Learning outcome:</b></p> <p>The aim of the module is to equip students with knowledge in four areas:</p> <ol style="list-style-type: none"> <li>1. risk models;</li> <li>2. pricing;</li> <li>3. reserving;</li> <li>4. risk sharing.</li> </ol> <p>After having successfully completed the module, students are familiar with fundamental terms and methods of non-life insurance mathematics. They</p> <ul style="list-style-type: none"> <li>• are familiar with and able to handle essential definitions and terms within non-life insurance mathematics;</li> <li>• have an overview of the most valuable problem statements of non-life insurance;</li> <li>• understand central aspects of risk theory;</li> <li>• know substantial pricing and reserving methods;</li> <li>• estimate ruin probabilities;</li> <li>• are acquainted with most important reinsurance forms and reinsurance pricing methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students have acquired fundamental competencies within non-life insurance. They are able to</p> <ul style="list-style-type: none"> <li>• evaluate and quantify fundamental risks;</li> <li>• model the aggregate loss with individual or collective model;</li> <li>• apply a basic inventory of solving approaches;</li> <li>• analyse and develop pricing models which mathematically are state of the art;</li> <li>• apply different reserving methods and calculate outstanding losses;</li> <li>• assess reinsurance contracts.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<p><b>Course: Lecture course with exercise session</b></p>	<p>4 WLH</p>

<b>Examination: Written examination (120 minutes)</b>		6 C
<b>Examination requirements:</b> Fundamental knowledge of non-life insurance mathematics		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 4 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> External lecturers at the Institute of Mathematical Stochastics <b>Accreditation:</b> By the German Actuarial Association (Deutsche Aktuarvereinigung e. V.), valid until winter semester 2017/18		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3044: Life insurance mathematics</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• essential notions of present values;</li> <li>• premiums and their present values;</li> <li>• the actuarial reserve.</li> </ul> <p>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. <a href="http://www.aktuar.de">www.aktuar.de</a>). To this end, the course is designed in view of current legislative and regulatory provisions of the Federal Republic of Germany.</p> <p><b>Learning outcome:</b></p> <p>After having successfully completed the module, students are familiar with fundamental terms and methods of life insurance mathematics. In particular they</p> <ul style="list-style-type: none"> <li>• assess cashflows in terms of financial and insurance mathematics;</li> <li>• apply methods of life insurance mathematics to problems from theory and practise;</li> <li>• characterise financial securities and insurance contracts in terms of cashflows;</li> <li>• have an overview of the most valuable problem statements of life insurance;</li> <li>• understand the stochastic interest structure;</li> <li>• master fundamental terms and notions of life insurance mathematics;</li> <li>• get an overview of most important problems in life insurance mathematics;</li> <li>• understand mortality tables and leaving orders within pension insurance;</li> <li>• know substantial pricing and reserving methods;</li> <li>• know the economic and legal requirements of private health insurance in Germany;</li> <li>• are acquainted with per-head loss statistics, present value factor calculation and biometric accounting principles.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students have acquired fundamental competencies within life insurance. They are able to</p> <ul style="list-style-type: none"> <li>• assess cashflows with respect to both collateral and risk under deterministic interest structure;</li> <li>• calculate premiums and provisions in life-, health- and pension-insurance;</li> <li>• understand the actuarial equivalence principle as base of actuarial valuation in life insurance;</li> <li>• apply and understand the actuarial equivalence principle for calculating premiums, actuarial reserves and ageing provisions;</li> <li>• calculate profit participation in life insurance;</li> <li>• master premium calculation in health insurance;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

<ul style="list-style-type: none"> <li>• calculate present value and settlement value of pension obligations;</li> <li>• find mathematical solutions to practical questions in life, health and pension insurance.</li> </ul>	
<b>Course: Lecture course with exercises</b>	4 WLH
<b>Examination: Written examination (120 minutes)</b>	6 C
<b>Examination requirements:</b> Fundamental knowledge of life insurance mathematics	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 4 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b>	
<b>Instructor:</b> External lecturers at the Institute of Mathematical Stochastics	
<b>Accreditation:</b> By the German Actuarial Association (Deutsche Aktuarvereinigung e. V.), valid until summer semester 2019	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3111: Introduction to analytic number theory</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Analytical number theory";</li> <li>• explain basic ideas of proof in the area "Analytical number theory";</li> <li>• illustrate typical applications in the area "Analytical number theory".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3111.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Analytic number theory"	

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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3112: Introduction to analysis of partial differential equations</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalized functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial differential equations;</li> <li>• use different theorems of function theory for solving partial differential equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial differential equations;</li> <li>• know the importance of partial differential equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Analysis of partial differential equations";</li> <li>• explain basic ideas of proof in the area "Analysis of partial differential equations";</li> <li>• illustrate typical applications in the area "Analysis of partial differential equations".</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3112.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Analysis of partial differential equations"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3113: Introduction to differential geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, areas and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Differential geometry";</li> <li>• explain basic ideas of proof in the area "Differential geometry";</li> <li>• illustrate typical applications in the area "Differential geometry".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>B.Mat.3113.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH
<b>Examination requirements:</b>	

Proof of knowledge and mastery of basic competencies in the area "Differential geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3114: Introduction to algebraic topology</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Algebraic topology";</li> <li>• explain basic ideas of proof in the area "Algebraic topology";</li> <li>• illustrate typical applications in the area "Algebraic topology".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH

<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes)		9 C
<b>Examination prerequisites:</b> B.Mat.3114.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b>		9 C 6 WLH
<b>Module B.Mat.3115: Introduction to mathematical methods in physics</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, <math>C^*</math> algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> <p>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.</p> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Mathematical methods of physics";</li> <li>• explain basic ideas of proof in the area "Mathematical methods of physics";</li> <li>• illustrate typical applications in the area "Mathematical methods of physics".</li> </ul>		<p><b>Workload:</b> Attendance time: 84 h Self-study time: 186 h</p>
<b>Course: Lecture course</b> (Lecture)		4 WLH
<p><b>Examination: Written or oral exam</b>written examination (120 minutes) or oral examination (appr. 20 minutes)</p> <p><b>Examination prerequisites:</b> B.Mat.3115.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Mathematical methods in physics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	

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<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3121: Introduction to algebraic geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Algebraic geometry";</li> <li>• explain basic ideas of proof in the area "Algebraic geometry";</li> <li>• illustrate typical applications in the area "Algebraic geometry".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3121.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Algebraic geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3122: Introduction to algebraic number theory</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>Z_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Algebraic number theory";</li> <li>• explain basic ideas of proof in the area "Algebraic number theory";</li> <li>• illustrate typical applications in the area "Algebraic number theory".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:            84 h</p> <p>Self-study time:            186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) <b>Examination prerequisites:</b> B.Mat.3122.Ue:Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3123: Introduction to algebraic structures</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Algebraic structures";</li> <li>• explain basic ideas of proof in the area "Algebraic structures";</li> <li>• illustrate typical applications in the area "Algebraic structures".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>B.Mat.3123.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	<p>9 C</p>

<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Algebraic structures"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3124: Introduction to groups, geometry and dynamical systems</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Groups, geometry and dynamical systems";</li> <li>• explain basic ideas of proof in the area "Groups, geometry and dynamical systems";</li> <li>• illustrate typical applications in the area "Groups, geometry and dynamical systems".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b>	9 C

<b>Examination prerequisites:</b> B.Mat.3124.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Groups, geometry and dynamical systems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3125: Introduction to non-commutative geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:            84 h</p> <p>Self-study time:            186 h</p>

<ul style="list-style-type: none"> <li>interpret these homological invariants geometrically and correlate them with each other;</li> <li>abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>discuss basic concepts of the area "Non-commutative geometry";</li> <li>explain basic ideas of proof in the area "Non-commutative geometry";</li> <li>illustrate typical applications in the area "Non-commutative geometry".</li> </ul>		
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Written or oral exam</b> <b>written examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3125.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Non-commutative geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1100, B.Mat.1200	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3131: Introduction to inverse problems</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computed tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Inverse problems";</li> <li>• explain basic ideas of proof in the area "Inverse problems";</li> <li>• illustrate typical applications in the area "Inverse problems".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: written examination (120 minutes) or oral examination (appr. 20 minutes)</b>	9 C

<b>Examination prerequisites:</b> B.Mat.3131.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Inverse problems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3132: Introduction to approximation methods</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Approximation methods";</li> <li>• explain basic ideas of proof in the area "Approximation methods" for one- and multidimensional data;</li> <li>• illustrate typical applications in the area of data approximation and data analysis.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>

<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes)		9 C
<b>Examination prerequisites:</b> B.Mat.3132.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Approximation methods"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3133: Introduction to numerics of partial differential equations</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Numerics of partial differential equations";</li> <li>• explain basic ideas of proof in the area "Numerics of partial differential equations";</li> <li>• illustrate typical applications in the area "Numerics of partial differential equations".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) <b>Examination prerequisites:</b> B.Mat.3133.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Numerics of partial differential equations"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3134: Introduction to optimisation</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Optimisation";</li> <li>• explain basic ideas of proof in the area "Optimisation";</li> <li>• illustrate typical applications in the area "Optimisation".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) <b>Examination prerequisites:</b> B.Mat.3134.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3137: Introduction to variational analysis</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Variational analysis";</li> <li>• explain basic ideas of proof in the area "Variational analysis";</li> <li>• illustrate typical applications in the area "Variational analysis".</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) (120 minutes) <b>Examination prerequisites:</b> B.Mat.3137.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Variational analysis"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3138: Introduction to image and geometry processing</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Image and geometry processing";</li> <li>• explain basic ideas of proof in the area "Image and geometry processing";</li> <li>• illustrate typical applications in the area "Image and geometry processing".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) <b>Examination prerequisites:</b> B.Mat.3138.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3139: Introduction to scientific computing / applied mathematics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Scientific computing / applied mathematics";</li> <li>• explain basic ideas of proof in the area "Scientific computing / applied mathematics";</li> <li>• illustrate typical applications in the area "Scientific computing / applied mathematics".</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: written examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3139.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b>	

Proof of knowledge and mastery of basic competencies in the area "Scientific computing / applied mathematics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1300	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3141: Introduction to applied and mathematical stochastics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Applied and mathematical stochastics";</li> <li>• explain basic ideas of proof in the area "Applied and mathematical stochastics";</li> <li>• illustrate typical applications in the area "Applied and mathematical stochastics".</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3141.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Applied and mathematical stochastics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3142: Introduction to stochastic processes</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Stochastic processes";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<ul style="list-style-type: none"> <li>• explain basic ideas of proof in the area "Stochastic processes";</li> <li>• illustrate typical applications in the area "Stochastic processes".</li> </ul>		
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) <b>Examination prerequisites:</b> B.Mat.3142.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Stochastic processes"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		9 C 6 WLH
<b>Module B.Mat.3143: Introduction to stochastic methods of econometrics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>The successful completion of modules of the cycle "Stochastic methods of econometrics" 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</p> <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Stochastic methods of econometrics";</li> <li>• explain basic ideas of proof in the area "Stochastic methods of econometrics";</li> <li>• illustrate typical applications in the area "Stochastic methods of econometrics".</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course (Lecture)</b>		4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3143.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Stochastic methods of econometrics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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not specified	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3144: Introduction to mathematical statistics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Mathematical statistics";</li> <li>• explain basic ideas of proof in the area "Mathematical statistics";</li> <li>• illustrate typical applications in the area "Mathematical statistics".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Written or oral examwritten examination (120 minutes) or oral examination (appr. 20 minutes)</b>	9 C

<b>Examination prerequisites:</b> B.Mat.3144.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Mathematical statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3145: Introduction to statistical modelling and inference</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Statistical modelling and inference";</li> <li>• explain basic ideas of proof in the area "Statistical modelling and inference";</li> <li>• illustrate typical applications in the area "Statistical modelling and inference".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h Self-study time: 186 h</p>
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Written or oral examoral examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3145.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Statistical modelling and inference"	
<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>

none	B.Mat.1400
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3146: Introduction to multivariate statistics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Multivariate statistics";</li> <li>• explain basic ideas of proof in the area "Multivariate statistics";</li> <li>• illustrate typical applications in the area "Multivariate statistics".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH

<b>Examination: Written or oral exam</b> written examination (120 minutes) or oral examination (appr. 20 minutes) <b>Examination prerequisites:</b> B.Mat.3146.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Multivariate statistics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3147: Introduction to statistical foundations of data science</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Statistical foundations of data science";</li> <li>• explain basic ideas of proof in the area "Statistical foundations of data science";</li> <li>• illustrate typical applications in the area "Statistical foundations of data science".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: written examination (120 minutes) or oral examination (appr. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3147.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of knowledge and mastery of basic competencies in the area "Statistical foundations of data science"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3311: Advances in analytic number theory</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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</p> <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Analytic number theory" confidently;</li> <li>• explain complex issues of the area "Analytic number theory";</li> <li>• apply methods of the area "Analytic number theory" to new problems in this area.</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course (Lecture)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3311.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Analytic number theory"		
<b>Admission requirements:</b>		<b>Recommended previous knowledge:</b>

none	B.Mat.3111
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3111 "Introduction to analytic number theory"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3312: Advances in analysis of partial differential equations</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial differential equations;</li> <li>• use different theorems of function theory for solving partial differential equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial differential equations;</li> <li>• know the importance of partial differential equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Analysis of partial differential equations" confidently;</li> <li>• explain complex issues of the area "Analysis of partial differential equations";</li> <li>• apply methods of the area "Analysis of partial differential equations" to new problems in this area.</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3312.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Analysis of partial differential equations"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3112	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3112 "Introduction to analysis of partial differential equations"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3313: Advances in differential geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Differential geometry" confidently;</li> <li>• explain complex issues of the area "Differential geometry";</li> <li>• apply methods of the area "Differential geometry" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>B.Mat.3313.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH
<b>Examination requirements:</b>	

Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Differential geometry"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3113
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3113 "Introduction to differential geometry"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	

<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute
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<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3314: Advances in algebraic topology</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Algebraic topology" confidently;</li> <li>• explain complex issues of the area "Algebraic topology";</li> <li>• apply methods of the area "Algebraic topology" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	9 C

<b>Examination prerequisites:</b> B.Mat.3314.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3114	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3114 "Introduction to algebraic topology"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b>		9 C
<b>Module B.Mat.3315: Advances in mathematical methods in physics</b>		6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, <math>C^*</math> algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> <p>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.</p> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Mathematical methods in physics" confidently;</li> <li>• explain complex issues of the area "Mathematical methods in physics";</li> <li>• apply methods of the area "Mathematical methods in physics" to new problems in this area.</li> </ul>		<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course</b> (Lecture)		4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>B.Mat.3315.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<p><b>Examination requirements:</b></p> <p>Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Mathematical methods in physics"</p>		
<p><b>Admission requirements:</b></p> <p>none</p>	<p><b>Recommended previous knowledge:</b></p> <p>B.Mat.3115</p>	

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<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> on an irregular basis	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3321: Advances in algebraic geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Algebraic geometry" confidently;</li> <li>• explain complex issues of the area "Algebraic geometry";</li> <li>• apply methods of the area "Algebraic geometry" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b>  <b>Examination prerequisites:</b>            B.Mat.3321.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C

<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3121	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3121 "Introduction to algebraic geometry"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3322: Advances in algebraic number theory</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>Z_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Algebraic number theory" confidently;</li> <li>• explain complex issues of the area "Algebraic number theory";</li> <li>• apply methods of the area "Algebraic number theory" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3322.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessionsungen	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3122
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3122 "Introduction to algebraic number theory"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3323: Advances in algebraic structures</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Algebraic structures" confidently;</li> <li>• explain complex issues of the area "Algebraic structures";</li> <li>• apply methods of the area "Algebraic structures" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>B.Mat.3323.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH

<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Algebraic structures"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3123	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3123 "Introduction to algebraic structures"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3324: Advances in groups, geometry and dynamical systems</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Groups, geometry and dynamical systems" confidently;</li> <li>• explain complex issues of the area "Groups, geometry and dynamical systems";</li> <li>• apply methods of the area "Groups, geometry and dynamical systems" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p>	<p>9 C</p>

B.Mat.3324.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Groups, geometry and dynamical systems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3124	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3124 "Introduction to groups, geometry and dynamical systems"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3325: Advances in non-commutative geometry</b></p>	<p>9 C 6 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
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<ul style="list-style-type: none"> <li>• interpret these homological invariants geometrically and correlate them with each other;</li> <li>• abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Non-commutative geometry" confidently;</li> <li>• explain complex issues of the area "Non-commutative geometry";</li> <li>• apply methods of the area "Non-commutative geometry" to new problems in this area.</li> </ul>		
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3325.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Non-commutative geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3125	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3125 "Introduction to non-commutative geometry"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3331: Advances in inverse problems</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Inverse problems" confidently;</li> <li>• explain complex issues of the area "Inverse problems";</li> <li>• apply methods of the area "Inverse problems" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3331.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Inverse problems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3131	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3131 "Introduction to inverse problems"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3332: Advances in approximation methods</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Approximation methods" confidently;</li> <li>• explain complex issues of the area "Approximation methods";</li> <li>• apply methods of the area "Approximation methods" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3332.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Approximation methods"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3132	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3132 "Introduction to approximation methods"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3333: Advances in numerics of partial differential equations</b></p>	<p>9 C 6 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Numerics of partial differential equations" confidently;</li> <li>• explain complex issues of the area "Numerics of partial differential equations";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
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<ul style="list-style-type: none"> <li>• apply methods of the area "Numerics of partial differential equations" to new problems in this area.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3333.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Numerics of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3133
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3133 "Introduction to numerics of partial differential equations"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3334: Advances in optimisation</b></p>	<p>9 C 6 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Optimisation" confidently;</li> <li>• explain complex issues of the area "Optimisation";</li> <li>• apply methods of the area "Optimisation" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
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<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3334.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3134
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3134 "Introduction to optimisation"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> Instructor: Lecturers at the Institute of Numerical and Applied Mathematics	



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3337: Advances in variational analysis</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Variational analysis" confidently;</li> <li>• explain complex issues of the area "Variational analysis";</li> <li>• apply methods of the area "Variational analysis" to new problems in this area.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3337.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Variational analysis"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3137
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3137 "Introduction in variational analysis"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3338: Advances in image and geometry processing</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Image and geometry processing" confidently;</li> <li>• explain complex issues of the area "Image and geometry processing";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<ul style="list-style-type: none"> <li>• apply methods of the area "Image and geometry processing" to new problems in this area.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3338.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3138
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3138 "Introduction to image and geometry processing"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3339: Advances in scientific computing / applied mathematics</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Scientific computing / applied mathematics" confidently;</li> <li>• explain complex issues of the area "Scientific computing / applied mathematics";</li> <li>• apply methods of the area "Scientific computing / applied mathematics" to new problems in this area.</li> </ul>	<p><b>Workload:</b> Attendance time: 84 h Self-study time: 186 h</p>
<p><b>Course: Lecture course</b> (Lecture)</p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3339.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	<p>9 C</p>
<p><b>Course: Exercise session</b> (Exercise)</p>	<p>2 WLH</p>
<p><b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Scientific computing / applied mathematics"</p>	

<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3139
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3139 "Introduction to scientific computing / applied mathematics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3341: Advances in applied and mathematical stochastics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Applied and mathematical stochastics" confidently;</li> <li>• explain complex issues of the area "Applied and mathematical stochastics";</li> <li>• apply methods of the area "Applied and mathematical stochastics" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:            84 h</p> <p>Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3341.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Applied and mathematical stochastics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3141	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3141 "Introduction to applied and mathematical stochastics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		



<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3342: Advances in stochastic processes</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Stochastic processes" confidently;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<ul style="list-style-type: none"> <li>• explain complex issues of the area "Stochastic processes";</li> <li>• apply methods of the area "Stochastic processes" to new problems in this area.</li> </ul>		
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3342.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Stochastic processes"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3142	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3142 "Introduction to stochastic processes"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		9 C 6 WLH
<b>Module B.Mat.3343: Advances in stochastic methods of econometrics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>The successful completion of modules of the cycle "Stochastic methods of econometrics" 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</p> <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Stochastic methods of econometrics" confidently;</li> <li>• explain complex issues of the area "Stochastic methods of econometrics";</li> <li>• apply methods of the area "Stochastic methods of econometrics" to new problems in this area.</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3343.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Stochastic methods of econometrics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3143	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b> 1 semester[s]	

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Usually subsequent to the module B.Mat.3143 "Introduction to stochastic methods of econometrics"	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3344: Advances in mathematical statistics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Mathematical statistics" confidently;</li> <li>• explain complex issues of the area "Mathematical statistics";</li> <li>• apply methods of the area "Mathematical statistics" to new problems in this area</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b>	9 C

B.Mat.3344.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Mathematical statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3144	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3144 "Introduction to mathematical statistics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		9 C
<b>Module B.Mat.3345: Advances in statistical modelling and inference</b>		6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Statistical modelling and inference" confidently;</li> <li>• explain complex issues of the area "Statistical modelling and inference";</li> <li>• apply methods of the area "Statistical modelling and inference" to new problems in this area.</li> </ul>		<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course</b> (Lecture)		4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>B.Mat.3345.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<p><b>Examination requirements:</b></p> <p>Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Statistical modelling and inference"</p>		
<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>	

none	B.Mat.3145
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3111 "Introduction to statistical modelling and inference"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module B.Mat.3346: Advances in multivariate statistics</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Multivariate statistics" confidently;</li> <li>• explain complex issues of the area "Multivariate statistics";</li> <li>• apply methods of the area "Multivariate statistics" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>9 C</p>

<b>Examination prerequisites:</b> B.Mat.3346.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Multivariate statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3146	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3146 "Introduction to multivariate statistics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Mat.3347: Advances in statistical foundations of data science</b>	9 C 6 WLH
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<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• handle methods and concepts of the area "Statistical foundations of data science" confidently;</li> <li>• explain complex issues of the area "Statistical foundations of data science";</li> <li>• apply methods of the area "Statistical foundations of data science" to new problems in this area.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:                  84 h                  Self-study time:                  186 h</p>
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<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> B.Mat.3347.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of advancement of knowledge and competencies acquired in the introductory module of the area "Statistical foundations of data science"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3147
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3147 "Introduction to statistical foundations of data science"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 6; Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul B.Phi.01: Basismodul Theoretische Philosophie</b></p> <p><i>English title: Basic Studies in Theoretical Philosophy</i></p>	<p>9 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>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.</p> <p>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 mindestens in Textform zu diskutieren.</p>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden</p>
<p><b>Lehrveranstaltung: 1. Einführungskurs in die theoretische Philosophie</b> (Vorlesung, Seminar)</p> <p><i>Angebotshäufigkeit:</i> Einführungskurs bevorzugt im Wintersemester</p>	<p>2 SWS</p>
<p><b>Prüfung: Klausur (45 Minuten), unbenotet</b></p> <p><b>Prüfungsanforderungen:</b></p> <p>Verständnis zentraler Begriffe, Probleme und Theorieansätze der theoretischen Philosophie und Fähigkeit, diese auf elementarem Niveau argumentativ verständlich darzulegen.</p>	<p>2 C</p>
<p><b>Lehrveranstaltung: 2. Proseminar zur theoretischen Philosophie</b></p> <p><b>Es muss <u>eine</u> der nachfolgenden Prüfungsformen (Klausur, Hausarbeit oder Essays) absolviert werden.</b></p>	<p>2 SWS</p>
<p><b>Prüfung: Hausarbeit (max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b></p> <p>Verständnis zentraler Begriffe, Probleme und Theorieansätze der theoretischen Philosophie. Darstellung und Diskussion von Themen der theoretischen Philosophie auf elementarem Niveau mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Essays (insgesamt max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b></p> <p>Verständnis zentraler Begriffe, Probleme und Theorieansätze der theoretischen Philosophie. Darstellung und Diskussion von Themen der theoretischen Philosophie auf elementarem Niveau mindestens in Textform.</p>	<p>7 C</p>

<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.) <b>Prüfungsanforderungen:</b> Verständnis zentraler Begriffe, Probleme und Theorieansätze der theoretischen Philosophie. Darstellung und Diskussion von Themen der theoretischen Philosophie auf elementarem Niveau mindestens in Textform.		7 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Christian Beyer	
<b>Angebotshäufigkeit:</b> jedes Semester; Einführungskurs bevorzugt im Wintersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 3	
<b>Maximale Studierendenzahl:</b> 100		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul B.Phi.02: Basismodul Praktische Philosophie</b></p> <p><i>English title: Basic Studies in Practical Philosophy</i></p>	<p>9 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>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.</p> <p>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 mindestens in Textform zu diskutieren.</p>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden</p> <p>Selbststudium: 214 Stunden</p>
<p><b>Lehrveranstaltung: Einführungskurs in die Praktische Philosophie</b> (Vorlesung, Seminar)</p> <p><i>Angebotshäufigkeit:</i> jedes Semester; Einführungskurs bevorzugt im Wintersemester</p>	<p>2 SWS</p>
<p><b>Prüfung: Klausur (45 Minuten), unbenotet</b></p> <p><b>Prüfungsanforderungen:</b></p> <p>Verständnis zentraler Begriffe, Probleme und Theorieansätze der praktischen Philosophie und Fähigkeit, diese auf elementarem Niveau argumentativ verständlich darzulegen.</p>	<p>2 C</p>
<p><b>Lehrveranstaltung: Proseminar zur Praktischen Philosophie</b></p> <p><b>Es muss <u>eine</u> der nachfolgenden Prüfungsformen (Klausur, Hausarbeit oder Essays) absolviert werden.</b></p>	<p>2 SWS</p>
<p><b>Prüfung: Klausur (120 Minuten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b></p> <p>Verständnis zentraler Begriffe, Probleme und Theorieansätze der praktischen Philosophie. Darstellung und Diskussion von Themen der praktischen Philosophie auf elementarem Niveau mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Essays (insgesamt max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b></p> <p>Verständnis zentraler Begriffe, Probleme und Theorieansätze der praktischen Philosophie. Darstellung und Diskussion von Themen der praktischen Philosophie auf elementarem Niveau mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Hausarbeit (max. 15 Seiten)</b></p>	<p>7 C</p>

<b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)	
<b>Prüfungsanforderungen:</b> Verständnis zentraler Begriffe, Probleme und Theorieansätze der praktischen Philosophie. Darstellung und Diskussion von Themen der praktischen Philosophie auf elementarem Niveau mindestens in Textform.	
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Holmer Steinfath
<b>Angebotshäufigkeit:</b> jedes Semester, Einführungskurs bevorzugt im Wintersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 3
<b>Maximale Studierendenzahl:</b> 100	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul B.Phi.03: Basismodul Geschichte der Philosophie</b></p> <p><i>English title: Basic Studies in History of Philosophy</i></p>	<p>9 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>1. In einem Einführungskurs (Vorlesung oder Einführungsseminar) erwerben die Studierenden einen Überblick über Epochen der Philosophiegeschichte, sie machen eine erste Bekanntschaft mit jeweils zentralen Themenbereichen und einzelnen klassischen Werken.</p> <p>2. In einem Proseminar (Basisseminar) erlangen die Studierenden Verständnis klassischer Texte der Philosophie sowie Grundfertigkeiten der Analyse eines Textes unter historischen und systematischen Gesichtspunkten.</p>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden</p> <p>Selbststudium: 214 Stunden</p>
<p><b>Lehrveranstaltung: 1. Einführungskurs in die Geschichte der Philosophie</b> (Vorlesung, Seminar)</p>	<p>2 SWS</p>
<p><b>Prüfung: Klausur (45 Minuten), unbenotet</b></p> <p><b>Prüfungsanforderungen:</b></p> <p>Überblick über Epochen der Philosophiegeschichte und elementares Verständnis zentraler Themen und klassischer philosophischer Texte sowie Fähigkeit, diese auf elementarem Niveau argumentativ verständlich darzulegen.</p>	<p>2 C</p>
<p><b>Lehrveranstaltung: 2. Proseminar zur Geschichte der Philosophie</b></p> <p><b>Es muss <u>eine</u> der nachfolgenden Prüfungsformen (Klausur, Hausarbeit oder Essays) absolviert werden.</b></p>	<p>2 SWS</p>
<p><b>Prüfung: Essays (insgesamt max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b></p> <p>Überblick über Epochen der Philosophiegeschichte, elementares Verständnis zentraler Themen und klassischer philosophischer Texte. Darstellung und Diskussion philosophiegeschichtlicher Themen auf elementarem Niveau mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Klausur (120 Minuten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b></p> <p>Überblick über Epochen der Philosophiegeschichte, elementares Verständnis zentraler Themen und klassischer philosophischer Texte. Darstellung und Diskussion philosophiegeschichtlicher Themen auf elementarem Niveau mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Hausarbeit (max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>regelmäßige Teilnahme an einem Proseminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p>	<p>7 C</p>

<b>Prüfungsanforderungen:</b> Überblick über Epochen der Philosophiegeschichte, elementares Verständnis zentraler Themen und klassischer philosophischer Texte. Darstellung und Diskussion philosophiegeschichtlicher Themen auf elementarem Niveau mindestens in Textform.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Bernd Ludwig	
<b>Angebotshäufigkeit:</b> jedes Semester; Einführungskurs bevorzugt im SoSe	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 3	
<b>Maximale Studierendenzahl:</b> 100		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Phi.05: Aufbauomodul Theoretische Philosophie</b> <i>English title: Advanced Studies in Theoretical Philosophy</i>	10 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden verfügen über fortgeschrittene Kenntnisse ausgewählter Themen und Theorien der theoretischen Philosophie sowie über die Fähigkeit der Darstellung und Diskussion systematischer Positionen und Probleme in mündlicher und mindestens in Textform.	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 244 Stunden
<b>Lehrveranstaltung: 1. Vorlesung oder Seminar zur theoretischen Philosophie</b>	2 SWS
<b>Lehrveranstaltung: 2. Seminar zur theoretischen Philosophie</b> <b>Zu beiden Lehrveranstaltungen ist je eine Prüfung zu wählen</b> , entweder die kleine Leistung oder <b>eine</b> Modulprüfung in Form einer Hausarbeit, von Essays oder einer Klausur. In welcher Lehrveranstaltung die Prüfung in Form einer kleinen Leistung abgelegt wird und in welcher in Form einer Hausarbeit, von Essays <b>oder</b> einer Klausur, ist frei wählbar.	2 SWS
<b>Prüfung: Kleine Leistung (max. 2 Seiten), unbenotet</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar <b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der theoretischen Philosophie und Fähigkeit, diese mindestens in kurzer Textform argumentativ verständlich darzulegen.	3 C
<b>Prüfung: Essays (insgesamt max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.) <b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der theoretischen Philosophie. Sachgemäße u. differenzierte Erörterung von Themen der theoretischen Philosophie mindestens in Textform.	7 C
<b>Prüfung: Hausarbeit (max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.) <b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der theoretischen Philosophie. Sachgemäße u. differenzierte Erörterung von Themen der theoretischen Philosophie mindestens in Textform.	7 C
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)	7 C

<b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der theoretischen Philosophie. Sachgemäße u. differenzierte Erörterung von Themen der theoretischen Philosophie mindestens in Textform.	
<b>Zugangsvoraussetzungen:</b> B.Phi.01	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Catrin Misselhorn
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 5
<b>Maximale Studierendenzahl:</b> 100	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Phi.06: Aufbaumodul Praktische Philosophie</b> <i>English title: Advanced Studies in Practical Philosophy</i>	10 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden verfügen über fortgeschrittene Kenntnisse ausgewählter Themen und Theorien der Praktischen Philosophie sowie über die Fähigkeit der Darstellung und Diskussion systematischer Positionen und Probleme in mündlicher und mindestens in Textform.	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 244 Stunden
<b>Lehrveranstaltung: 1. Vorlesung oder Seminar zur praktischen Philosophie</b>	2 SWS
<b>Lehrveranstaltung: 2. Seminar zur praktischen Philosophie</b> <b>Zu beiden Lehrveranstaltungen ist je eine Prüfung zu wählen</b> , entweder die kleine Leistung oder <b>eine</b> Modulprüfung in Form einer Hausarbeit, von Essays oder einer Klausur. In welcher Lehrveranstaltung die Prüfung in Form einer kleinen Leistung abgelegt wird und in welcher in Form einer Hausarbeit, von Essays <b>oder</b> einer Klausur, ist frei wählbar.	2 SWS
<b>Prüfung: Kleine Leistung (max. 2 Seiten), unbenotet</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar <b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der praktischen Philosophie und Fähigkeit, diese mindestens in kurzer Textform argumentativ verständlich darzulegen.	3 C
<b>Prüfung: Essay (insgesamt max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.) <b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der praktischen Philosophie. Sachgemäße u. differenzierte Erörterung von Themen der praktischen Philosophie mindestens in Textform.	7 C
<b>Prüfung: Hausarbeit (max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.) <b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der praktischen Philosophie. Sachgemäße u. differenzierte Erörterung von Themen der praktischen Philosophie mindestens in Textform.	7 C
<b>Prüfung: Klausur (120 Minuten)</b> <b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)	7 C

<b>Prüfungsanforderungen:</b> Eingehende Kenntnis ausgewählter Probleme und Theorien der praktischen Philosophie. Sachgemäße u. differenzierte Erörterung von Themen der praktischen Philosophie mindestens in Textform.		
<b>Zugangsvoraussetzungen:</b> B.Phi.02	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Holmer Steinfath	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 5	
<b>Maximale Studierendenzahl:</b> 100		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul B.Phi.07: Aufbauomodul Geschichte der Philosophie</b></p> <p><i>English title: Advanced Studies in History of Philosophy</i></p>	<p>10 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>Die Studierenden verfügen über fortgeschrittene Kenntnisse klassischer Texte aus unterschiedlichen Epochen sowie über die Fähigkeit der Darstellung und Behandlung klassischer philosophischer Positionen und Probleme unter historischen und systematischen Gesichtspunkten in mündlicher und mindestens in Textform. Sie können philosophiehistorische Texte hinsichtlich ihrer Struktur analysieren, ihre wesentlichen Aussagen und Argumente erfassen und in ihren historischen und systematischen Interpretationsrahmen einordnen.</p>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden Selbststudium: 244 Stunden</p>
<p><b>Lehrveranstaltung: 1. Vorlesung oder Seminar zur Geschichte der Philosophie</b></p>	<p>2 SWS</p>
<p><b>Lehrveranstaltung: 2. Seminar zur Geschichte der Philosophie</b></p> <p><b>Zu beiden Lehrveranstaltungen ist je eine Prüfung zu wählen</b>, entweder die kleine Leistung oder <b>eine</b> Modulprüfung in Form einer Hausarbeit, von Essays oder einer Klausur. In welcher Lehrveranstaltung die Prüfung in Form einer kleinen Leistung abgelegt wird und in welcher in Form einer Hausarbeit, von Essays <b>oder</b> einer Klausur, ist frei wählbar.</p>	<p>2 SWS</p>
<p><b>Prüfung: Kleine Leistung (max. 2 Seiten), unbenotet</b></p> <p><b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar</p> <p><b>Prüfungsanforderungen:</b> Eingehende Kenntnisse klassischer philosophischer Texte aus unterschiedlichen Epochen und Fähigkeit, philosophiegeschichtliche Themen mindestens in kurzer Textform argumentativ verständlich darzulegen.</p>	<p>3 C</p>
<p><b>Prüfung: Essays (insgesamt max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b> Eingehende Kenntnisse klassischer philosophischer Texte aus unterschiedlichen Epochen. Sachgemäße u. differenzierte Erörterung von philosophiegeschichtlichen Themen mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Hausarbeit (max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.)</p> <p><b>Prüfungsanforderungen:</b> Eingehende Kenntnisse klassischer philosophischer Texte aus unterschiedlichen Epochen. Sachgemäße u. differenzierte Erörterung von philosophiegeschichtlichen Themen mindestens in Textform.</p>	<p>7 C</p>
<p><b>Prüfung: Klausur (120 Minuten)</b></p>	<p>7 C</p>

<b>Prüfungsvorleistungen:</b> regelmäßige Teilnahme, sofern Seminar; kleinere Leistung mindestens in Textform (max. 2 S.; Protokoll, Kurzreferat o.ä.) <b>Prüfungsanforderungen:</b> Eingehende Kenntnisse klassischer philosophischer Texte aus unterschiedlichen Epochen. Sachgemäße u. differenzierte Erörterung von philosophiegeschichtlichen Themen mindestens in Textform.	
<b>Zugangsvoraussetzungen:</b> B.Phi.03	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Bernd Ludwig
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 5
<b>Maximale Studierendenzahl:</b> 100	



<b>Georg-August-Universität Göttingen</b> <b>Modul B.Phi.18a: Vertiefte Bearbeitung philosophischer Themen für HörerInnen aller Fächer</b> <i>English title: Detailed Philosophical Studies</i>		6 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Studierende aller Fächer erweitern ihre fachlichen Kompetenzen durch ausgewählte Themen mit allgemein philosophischem Charakter z.B. aus den Gebieten der Erkenntnis- und Wissenschaftstheorie, der Sprachphilosophie, der Ethik und der Politischen Philosophie.  Die Studierenden besitzen die Fähigkeit, <ul style="list-style-type: none"> <li>• die wesentlichen Aussagen und Argumente in philosophischen Texten zu erfassen,</li> <li>• über philosophische Probleme mit wissenschaftlicher Präzision nachzudenken und</li> <li>• philosophische Positionen auf der Basis aktueller Fachliteratur unter Abwägung der relevanten Thesen und Argumente mindestens in Textform darzustellen und zu diskutieren.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden
<b>Lehrveranstaltung: Vorlesung, Proseminar, Seminar oder Hauptseminar</b> Es muss <b>eine</b> der nachfolgenden Prüfungsformen (Hausarbeit oder Essay) absolviert werden.		
<b>Prüfung: Essays (insgesamt max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> kleinere Leistung mindestens in Textform (max. 2 Seiten)		6 C
<b>Prüfung: Hausarbeit (max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> kleinere Leistung mindestens in Textform (max. 2 Seiten)		6 C
<b>Prüfungsanforderungen:</b> Verständnis zentraler Begriffe, Probleme und Theorieansätze auf einem Gebiet der Philosophie. Darstellung und Diskussion ausgewählter Probleme mindestens in Textform.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Bei Seminaren und Hauptseminaren: hinreichende Vorkenntnisse auf dem jeweiligen Gebiet (ggf. nach Rücksprache mit den Dozierenden)	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Christian Beyer	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 6	
<b>Maximale Studierendenzahl:</b>		

nicht begrenzt	
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<b>Georg-August-Universität Göttingen</b> <b>Modul B.Phi.19a: Spezielle Themen der Philosophie für HörerInnen aller Fächer</b> <i>English title: Special Philosophical Topics</i>		3 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Studierende aller Fächer erweitern ihre fachlichen Kompetenzen durch ausgewählte Themen mit allgemein philosophischem Charakter z.B. aus den Gebieten der Erkenntnis- und Wissenschaftstheorie, der Sprachphilosophie, der Ethik und der Politischen Philosophie.  Die Studierenden besitzen die Fähigkeit, <ul style="list-style-type: none"> <li>• die wesentlichen Aussagen und Argumente in philosophischen Texten zu erfassen,</li> <li>• über philosophische Probleme mit wissenschaftlicher Präzision nachzudenken und</li> <li>• philosophische Positionen in knapper Form mündlich und mindestens in Textform zu präsentieren und zu diskutieren.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Vorlesung, Proseminar, Seminar oder Hauptseminar</b>		
<b>Prüfung: Referat (ca. 20 Min.) mit Ausarbeitung mindestens in Textform (max. 3 Seiten) oder Essay (max. 3 Seiten) oder Klausur (ca. 45 Minuten), unbenotet</b> <b>Prüfungsanforderungen:</b> Verständnis zentraler Begriffe, Probleme und Theorieansätze auf einem Gebiet der Philosophie. Fähigkeit zur strukturierten Darstellung und Diskussion eines eng umgrenzten Themas.		3 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Bei Seminaren und Hauptseminaren: hinreichende Vorkenntnisse auf dem jeweiligen Gebiet (ggf. nach Rücksprache mit den Dozierenden)	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Catrin Misselhorn	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

<b>Georg-August-Universität Göttingen</b>		8 C
<b>Module B.Phy.1551: Introduction to Astrophysics</b>		6 WLH
<b>Learning outcome, core skills:</b> After successful completion of the module students are familiar with the basic concepts of astrophysics in observation and theory. In particular, they <ul style="list-style-type: none"> <li>• have gained an overview of observational techniques in astronomy</li> <li>• understand the basic physics of the formation, structure and evolution of stars and planets have learned about the classification and structure of normal and active galaxies</li> <li>• understand the basic physics of homogeneous cosmology and cosmological structure formation</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 156 h
<b>Course: Lecture and exercises for introduction to astrophysics</b>		
<b>Examination: oral (approx. 30 minutes) or written (120 min.) exam</b> <b>Examination prerequisites:</b> At least 50% of the homework of the excercises have to be solved successfully. <b>Examination requirements:</b> Observational techniques, Planets and exoplanets, planet formation, stellar formation, structure and evolution, galaxies, AGN and quasars, cosmology, structure formation		8 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English, German	<b>Person responsible for module:</b> Prof. Dr. Jens Niemeyer	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> three times	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1	
<b>Maximum number of students:</b> 120		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Phys.5601: Theoretical and Computational Neuroscience I</b> <i>English title: Theoretical and Computational Neuroscience I</i>		3 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sollten die Studierenden... <ul style="list-style-type: none"> <li>• ein vertieftes Verständnis folgender Themen entwickelt haben: TCN I: biophysikalische Grundlagen neuronaler Anregbarkeit, mathematische Grundlagen neuronaler Anregbarkeit, Input-Output Beziehungen und Bifurkationen, Klassifizierung, Existenz, Stabilität und Koexistenz synchroner und asynchroner Zustände in spikenden neuronalen Netzwerken;</li> <li>• Methoden und Methodenentwicklung für die Analyse hochdimensionaler Modelle ratenkodierter Einheiten in Feldmodellen verstehen;</li> <li>• die Handhabung von Bifurkationsszenarien und zugehörigen Instabilitäten verstanden haben.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
<b>Lehrveranstaltung: Collective Dynamics Biological Neural Networks I (Vorlesung)</b>		
Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:		
<b>Prüfung: Klausur (120 Minuten)</b>		3 C
<b>Prüfung: Mündlich Mündliche Prüfung (ca. 30 Minuten)</b>		3 C
<b>Prüfung: Vortrag (2 Wochen Vorbereitungszeit) (30 Minuten)</b>		3 C
<b>Prüfungsanforderungen:</b> Grundlagen der Membranbiophysik; Bifurkationen anregbarer Systeme; Verständnis der Grundlagen der Modellierungsansätze der Neurophysik; kollektive Zustände spikender neuronaler Netzwerke; insbesondere Synchronizität; Balanced State; Phase-Locking und diesen Zuständen unterliegenden lokalen und Netzwerkeigenschaften; Netzwerktopologie; Delays; inhibitorische und exzitatorische Kopplung; sparse random networks		
<b>Zugangsvoraussetzungen:</b> keine		<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Englisch		<b>Modulverantwortliche[r]:</b> Prof. Dr. Fred Wolf
<b>Angebotshäufigkeit:</b> jedes Wintersemester		<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> dreimalig		<b>Empfohlenes Fachsemester:</b> Bachelor: 4 - 6; Master: 1
<b>Maximale Studierendenzahl:</b> 90		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.Phys.5602: Theoretical and Computational Neuroscience II</b> <i>English title: Theoretical and Computational Neuroscience II</i>	3 C 2 SWS
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<b>Lernziele/Kompetenzen:</b> Nach erfolgreichem Absolvieren des Moduls sollten Studierende... <ul style="list-style-type: none"> <li>das vertiefte Verständnis folgender Themen entwickelt haben: TCN II: Grundlagen neuronaler Anregbarkeit, Input-Output Beziehungen bei Einzelneuronen, eindimensionale Feldmodelle (Feature Selectivity, Contrastinvariance), zweidimensionale Feldmodell (Zusammenwirken von kurz- und langreichweitigen Verbindungen sowie lokaler Nichtlinearitäten), Amplitudengleichungen und ihre Lösungen;</li> <li>Methoden und Methodenentwicklung für die Analyse spikender neuronaler Netzwerke mit und ohne Delays, Handhabung von Bifurkationsszenarien und zugehörigen Instabilitäten verstehen.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 62 Stunden
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<b>Lehrveranstaltung: Collective Dynamics Biological Neural Networks II (Vorlesung)</b>	
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Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:

<b>Prüfung: Klausur (120 Minuten)</b>	3 C
<b>Prüfung: Mündlich (ca. 30 Minuten)</b>	3 C
<b>Prüfung: Seminarvortrag (2 Wochen Vorbereitungszeit) (30 Minuten)</b>	3 C

<b>Prüfungsanforderungen:</b> Ratenmodelle von Einzelneuronen; Feldansatz in der theoretischen Neurophysik; Grundlagen der Bifurkationen anregbarer System; Verständnis der Grundlagen der Modellierungsansätze der Neurophysik; Zusammenhang diskrete/kontinuierliche Modelle; kollektive Zustände ein- und zweidimensionaler Feldmodelle, insbesondere ring model of feature selectivity; orientation preference maps.	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Fred Wolf
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> dreimalig	<b>Empfohlenes Fachsemester:</b> Bachelor: 4 - 6; Master: 1
<b>Maximale Studierendenzahl:</b> 90	

<b>Georg-August-Universität Göttingen</b>		3 C
<b>Module B.Phy.5651: Advanced Computational Neuroscience</b>		2 WLH
<b>Learning outcome, core skills:</b> Participants in the course can explain and relate biological foundations and mathematical modelling of selected (neuronal) algorithms for learning and pattern formation.  Based on the the algorithms' properties, they can discuss and derive possible technical applications (robots).		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Advanced Computational Neuroscience I (Lecture)</b>		
<b>Examination: Written examination (90 Min.) or oral examination (approx. 20 Min.)</b> <b>Examination requirements:</b> Algorithms for learning: <ul style="list-style-type: none"> <li>• Unsupervised Learning (Hebb, Differential Hebb),</li> <li>• Reinforcement Learning,</li> <li>• Supervised Learning</li> </ul> Algorithms for pattern formation.  Biological motivation and technical Application (robots).		3 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Basics Computational Neuroscience	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Florentin Andreas Wörgötter	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> three times	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> 50		
<b>Additional notes and regulations:</b> Hinweis: Die B.Phy.5652 kann als vorlesungsbegleitendes Praktikum besucht werden.		

<b>Georg-August-Universität Göttingen</b> <b>Module B.Phy.5652: Advanced Computational Neuroscience II</b>	3 C 2 WLH
<b>Learning outcome, core skills:</b> Participants in the course can implement, test, and evaluate the properties of selected (neuronal) algorithms for learning and pattern formation.	<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Advanced Computational Neuroscience II</b>	
<b>Examination: 4 Protocols (max. 3 Pages) and Presentations (ca. 10 Min.), not graded</b> <b>Examination requirements:</b> Algorithms for learning: <ul style="list-style-type: none"> <li>• Unsupervised Learning (Hebb, Differential Hebb),</li> <li>• Reinforcement Learning,</li> <li>• Supervised Learning</li> </ul> Algorithms for pattern formation. Biological motivation and technical Application (robots). <i>For each of the 4 programming assignments 1 protocol (ca. 3 pages) and 1 oral presentations (demonstration and discussion of the program, ca. 10 min).</i>	3 C
<b>Admission requirements:</b> B.Phy.5651 (can be taken in parallel to B.Phy.5652)	<b>Recommended previous knowledge:</b> Programming in C++, basic numerical algorithms, Grundlagen Computational Neuroscience B.Phy.5504: Computational Physics (Scientific Computing)
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Florentin Andreas Wörgötter
<b>Course frequency:</b> unregelmäßig	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> three times	<b>Recommended semester:</b> Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> 24	



<b>Georg-August-Universität Göttingen</b> <b>Module B.Phy.5676: Computer Vision and Robotics</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> After successful completion of this module, students are familiar with <ul style="list-style-type: none"> <li>the basic concepts of computer vision (CV),</li> <li>low level hardware components and their functions,</li> <li>building and programming a robot, and</li> <li>computer vision and robotics algorithms.</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Introduction to Computer Vision and Robotics (Lecture)</b> <i>Contents:</i> On-Off Controller, PID Controller, Moving Average Filter, Exponential Moving Average Filter, Kalman Filter, A*, Dijkstra, RRT, Q-Learning, Inverse and Forward Kinematics, Movement Generation Methods, Smoothing and Median Filtering, Bilateral Filtering, Non-Local Means, Connected Components, Morphological Operators, Line Detection, Circle Detection, Feature Detection, Advanced image segmentation algorithms.		2 WLH
<b>Course: Practical Course on Computer Vision and Robotics (Lecture)</b> <i>Contents:</i> Building a robot, solving a graph problem using the robot and executing the found solution by the robot in a real-world scenario involving perception and navigation		2 WLH
<b>Course: Tutorial on Computer Vision and Robotics (Tutorial)</b> <i>Contents:</i> In the accompanying tutorial sessions students deepen and broaden their knowledge from the lectures		2 WLH
<b>Examination: Written report (approx. 10 p.) and Oral Exam (approx. 30 minutes)</b> <b>Examination requirements:</b> Written report requirements: The students must be able <ul style="list-style-type: none"> <li>to describe their project in a written report</li> <li>to explain given problems and used solutions for navigation- and perception problems of robots</li> </ul> Oral Examination requirements: The students must be able <ul style="list-style-type: none"> <li>to repeat and explain lecture material</li> <li>to explain control algorithms for a robot, and</li> <li>to identify and understand low level hardware components as robot sensors and actuators.</li> </ul>		9 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Programming in Python	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Florentin Andreas Wörgötter	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b>	<b>Recommended semester:</b>	

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three times	Bachelor: 5 - 6; Master: 1 - 4
<b>Maximum number of students:</b> 24	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-BWL.0014: Rechnungslegung der Unternehmung</b> <i>English title: Financial Accounting</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Gegenstand der Veranstaltung ist die Vermittlung der Grundlagen externer Rechnungslegung nach Maßgabe handelsrechtlicher und internationaler Vorschriften (International Financial Reporting Standards (IFRS)). Mit erfolgreichem Abschluss der Veranstaltung haben Studierende folgende Kompetenzen erworben: <ul style="list-style-type: none"> <li>• Kenntnis der Grundzüge handelsrechtlicher und internationaler Rechnungslegung sowie markanter Unterschiede und grundlegender Entwicklungslinien,</li> <li>• Auswertung und Interpretation der entsprechenden Rechenwerke und Verwendung für analytische, entscheidungsunterstützende Zwecke.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Rechnungslegung der Unternehmung (Vorlesung)</b>		2 SWS
<b>Lehrveranstaltung: Rechnungslegung der Unternehmung (Übung)</b>		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> Von Studierenden wird der Nachweis der Kenntnis der Grundlagen der Rechnungslegung nach handelsrechtlichen Grundsätzen und nach International Financial Reporting Standards im Spannungsfeld nationaler Institutionen und internationaler Konvergenzbestrebungen erwartet. Dies umfasst auch die Lösung konkreter Fallbeispiele unter Einbeziehung handelsrechtlicher oder internationaler Rechnungslegungsvorschriften.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-OPH.0005 Jahresabschluss	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Jörg-Markus Hitz	
<b>Angebotshäufigkeit:</b> jedes 3. Semester; mit Wiederholungsklausur im Folgesemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 4	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-BWL.0023: Grundlagen der Versicherungstechnik</b> <i>English title: Actuarial Techniques</i>	6 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden erwerben die folgenden Fähigkeiten und Kenntnisse: <ul style="list-style-type: none"> <li>• Kenntnis und Verständnis der Funktionsweise der Versicherungsmärkte,</li> <li>• Kenntnis und Verständnis der Geschäftsmodelle und der technischen Grundlagen in der Lebens-, Kranken-, Schadens- und Rückversicherung sowie in der Betrieblichen Altersversorgung,</li> <li>• Kenntnis und Verständnis des Risikomanagements und der Solvabilitätsvorschriften incl. Methoden der Risikobewertung,</li> <li>• Kenntnis und Verständnis der Finanzierungsvorgänge incl. Rückstellungsbildung in der Versicherungswirtschaft,</li> <li>• Fähigkeit, der Bewertung der zentralen Unterschiede in den Geschäftsmodellen der privaten Versicherungswirtschaft, der gesetzlichen Versicherungssysteme und der Kreditwirtschaft,</li> <li>• Kenntnis des Instrumentariums der Risikopolitik eines Versicherungsunternehmens, auch anhand konkreter praktischer Beispiele,</li> <li>• Fähigkeit, einfache Berechnungen zur Versicherungstechnik vorzunehmen.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden
<b>Lehrveranstaltung: Grundlagen der Versicherungstechnik (Vorlesung)</b> <i>Inhalte:</i> <ol style="list-style-type: none"> <li>1. Begriffsbestimmungen, Struktur und Elemente des Risikotransfers;</li> <li>2. Elemente der Risikopolitik (u.a. Grundlagen der Prämienkalkulation und -differenzierung, Risikoauslese und Underwriting, Reservierungspolitik, Schadenmanagement, Rück- und Mitversicherung,);</li> <li>3. Geschäftsmodelle der Versicherungssparten (Lebensversicherung, Krankenversicherung, Schadenversicherung, Rückversicherung);</li> <li>4. Risikomanagement und Solvabilitätsvorschriften, insbesondere Solvency II;</li> <li>5. Finanzierung und Kapitalanlage</li> </ol>	2 SWS
<b>Prüfung: Klausur (120 Minuten)</b>	6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Nachweis von Kenntnissen der Funktion eines Versicherungsmarktes und seiner wesentlichen Determinanten und Begriffe,</li> <li>• Nachweis von Kenntnissen im Risikomanagement, der Solvabilitätsanforderungen und Risikobewertung,</li> <li>• Nachweis von Kenntnissen der Risikopolitik und der Geschäftsmodelle der Versicherungssparten,</li> <li>• Nachweis von Kenntnissen der Finanzierung des Risikotransfers,</li> <li>• Bewertung der Rolle der Versicherungswirtschaft zum Markt der Kreditwirtschaft und der gesetzlichen Versicherungssysteme,</li> <li>• Einfache Berechnungen zur Versicherungstechnik.</li> </ul>	

<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Martin Balleer
<b>Angebotshäufigkeit:</b> in der Regel jedes zweite Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-BWL.0038: Supply Chain Management</b> <i>English title: Supply Chain Management</i>	6 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Nach erfolgreicher Teilnahme des Moduls sind die Studierenden in der Lage, 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.	<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden
<b>Lehrveranstaltung: Supply Chain Management (Vorlesung)</b> <i>Inhalte:</i> <ol style="list-style-type: none"> <li>1. Begriffliche Grundlagen des Supply Chain Managements</li> <li>2. Analyserahmen für die Ausgestaltung der Supply Chain           <ul style="list-style-type: none"> <li>• Der Management-Zyklus</li> <li>• Elemente und Strukturen des entscheidungsorientierten Ansatzes</li> <li>• Entscheidungsfelder des Supply Chain Managements</li> <li>• Zielgrößen des Supply Chain Managements</li> <li>• Analyse der Einflussfaktoren</li> </ul> </li> <li>3. Koordination der Supply Chain           <ul style="list-style-type: none"> <li>• Begriffliche Grundlagen</li> <li>• Transaktionale versus relationale Koordination</li> <li>• Supplier Relationship Management</li> <li>• Beziehungsstile im Business to Business Geschäft</li> </ul> </li> <li>4. Standortplanung           <ul style="list-style-type: none"> <li>• Ziele, Einflussfaktoren und Optionen der Lagerstruktur</li> <li>• Methoden zur Lösung von Standortproblemen</li> </ul> </li> <li>5. Prognose der Nachfrage           <ul style="list-style-type: none"> <li>• Elemente eines Prognosesystems</li> <li>• Regressionsanalyse im Rahmen der Kausalanalyse</li> <li>• Grundlagen der Zeitreihenanalyse</li> <li>• Exponentielle Glättung Saisonmodell</li> </ul> </li> <li>6. Bestellmengenplanung           <ul style="list-style-type: none"> <li>• Bestellentscheidungen bei deterministischer Nachfrage</li> <li>• Bestellentscheidungen bei stochastischer Nachfrage</li> <li>• Das Joint Economic Lot Size (JELS) Modell</li> </ul> </li> <li>7. Technologische Voraussetzungen           <ul style="list-style-type: none"> <li>• Elektronischer Datenaustausch</li> <li>• Standardisierung</li> <li>• RFID</li> </ul> </li> </ol>	2 SWS

<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> 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.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-BWL.0005 Marketing	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Waldemar Toporowski	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 4 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		
<b>Bemerkungen:</b> Je nach Kapazität findet eine zusätzliche Übung mit Fallstudien statt. Informationen dazu stehen zu Beginn des Semesters im UniVz.		

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module B.WIWI-BWL.0087: International Marketing</b>		2 WLH
<b>Learning outcome, core skills:</b> After successful attendance the students understand the foundations of international marketing as well as the diverse environments of global markets. They are able to explain and the central elements of the international decision-making process, such as country and entry mode selection. Moreover, they are able to analyze and compare the attractiveness of different countries and recommend tailored marketing program strategies.		<b>Workload:</b> Attendance time: 28 h Self-study time: 152 h
<b>Course: International Marketing (Lecture)</b> <i>Contents:</i> <ul style="list-style-type: none"> <li>• Introduction to international marketing</li> <li>• Social and cultural environments</li> <li>• Political, legal, and regulatory environments</li> <li>• Assessing global marketing opportunities</li> <li>• International marketing strategy (country selection, entry-modes, international marketing mix)</li> <li>• Branding across cultures</li> </ul> <p>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, &amp; 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.</p>		2 WLH
<b>Examination: Written examination (90 minutes)</b>		6 C
<b>Examination requirements:</b> The written exam assesses students' understanding of the course content as well as their ability to apply their knowledge to case studies.		
<b>Examples:</b> <ul style="list-style-type: none"> <li>• Comparing different approaches of cultural difference assessment</li> <li>• Assessing a country's competitive environment</li> <li>• Recommending entry modes for different countries</li> </ul>		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Yasemin Boztug	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b>	<b>Recommended semester:</b>	



twice	3 - 6
<b>Maximum number of students:</b> not limited	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0001: Mikroökonomik II</b> <i>English title: Microeconomics II</i>	6 C 5 SWS
<b>Lernziele/Kompetenzen:</b> Nach erfolgreicher Absolvierung der Veranstaltung sind Studierende in der Lage: <ul style="list-style-type: none"> <li>• verschiedene Marktformen voneinander zu unterscheiden und deren Wohlfahrtseffekte zu analysieren,</li> <li>• zwischen der Gleichgewichtsanalyse eines einzelnen Marktes und der Analyse des allgemeinen Gleichgewichts aller Märkte zu unterscheiden und selbstständig anzuwenden,</li> <li>• das Prinzip intertemporaler Entscheidungen der Haushalte zu verstehen und in die optimale Entscheidung der Haushalte einzubeziehen,</li> <li>• die grundlegenden Zusammenhänge von Risiko und Versicherungsmärkten zu verstehen und in die optimale Entscheidung der Haushalte einzubeziehen,</li> <li>• die Grundlagen simultaner und sequentieller Spieltheorie zu verstehen und selbstständig anzuwenden,</li> <li>• die Konsequenzen asymmetrischer Informationen für das Verhalten der Marktteilnehmer zu analysieren.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 70 Stunden Selbststudium: 110 Stunden
<b>Lehrveranstaltung: Mikroökonomik II (Vorlesung)</b> <i>Inhalte:</i> <ul style="list-style-type: none"> <li>• Marktgleichgewicht bei vollkommener Konkurrenz und im Monopol: Grafische Analyse des Marktgleichgewichts und der allgemeinen Wohlfahrt in Abhängigkeit von der Marktform.</li> <li>• Monopolistische Preisdifferenzierung: Analyse von Preis-, Mengen- und Wohlfahrtseffekten.</li> <li>• Allgemeines Gleichgewicht: Grafische Analyse des allgemeinen Marktgleichgewichts mithilfe der Edgeworth-Box. Definition des Gesetzes von Walras sowie des ersten und zweiten Satzes der Wohlfahrtsökonomik.</li> <li>• Ersparnis und Investition: Mathematische und grafische Abhandlung der intertemporalen Budgetgleichung der Haushalte sowie der optimalen Konsum- und Produktionsentscheidungen.</li> <li>• Risiko und Versicherung: Mathematische und grafische Analyse der Entscheidung von Haushalten unter Unsicherheit. Einführung der Erwartungsnutzenhypothese und der von-Neumann-Morgenstern-Nutzenfunktion.</li> <li>• Oligopoltheorie: Mathematische und grafische Analyse von Cournot-, Stackelberg- und Bertrand-Gleichgewicht.</li> <li>• Spieltheorie: Spiele in Normalform. Bestimmung dominanter Strategien und Nash-Gleichgewicht. Sequentielle Entscheidungen. Analyse sequentieller Spiele mithilfe des Entscheidungsbaumes.</li> <li>• Asymmetrische Information: Analyse des Verhaltens von Marktteilnehmern im Fall von asymmetrisch verteilter Information. Moralisches Risiko (Moral hazard) und adverse Selektion.</li> </ul>	3 SWS

<b>Lehrveranstaltung: Mikroökonomik II (Tutorium)</b> <i>Inhalte:</i> In den Übungen werden die Inhalte der Vorlesung anhand von Aufgaben wiederholt und vertieft.		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Aufgaben sind sowohl rechnerisch als auch grafisch und verbal intuitiv zu lösen,</li> <li>• Nachweis grundlegender Kenntnisse des Wettbewerbsgleichgewichts eines Marktes und des allgemeinen Gleichgewichts, insbesondere der Rolle des Preises für die Markträumung,</li> <li>• Nachweis der Fähigkeit zur grafischen und mathematischen Analyse verschiedener Marktformen und deren Wohlfahrtseffekte,</li> <li>• Nachweis grundlegender Kenntnisse der Spieltheorie und Oligopoltheorie und der Fähigkeit der Bestimmung der optimalen Strategie der Marktteilnehmer,</li> <li>• Nachweis der Fähigkeit zur Bewertung der Risikoeinstellung von Marktteilnehmern und der Konsequenzen für die optimale Entscheidung.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Modul B.WIWI-OHP.0007: Mikroökonomik I	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Claudia Keser, Prof. Dr. Udo Kreickemeier, Prof. Dr. Robert Schwager, Prof. Dr. Sebastian Vollmer	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0002: Makroökonomik II</b> <i>English title: Macroeconomics II</i>	6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden: <ul style="list-style-type: none"> <li>• können die außenwirtschaftlichen Beziehungen einer Volkswirtschaft systematisch erfassen,</li> <li>• sind in der Lage, ein gesamtwirtschaftliches Modell durch die Beziehungen zum Ausland zu erweitern und anhand dieses Modells die Wirkung verschiedener wirtschaftspolitischer Maßnahmen in einer offenen Volkswirtschaft zu diskutieren,</li> <li>• kennen die Eigenschaften verschiedener Währungssysteme und können deren Vor- und Nachteile unter Einbeziehung ihres Einflusses auf die Wirkung wirtschaftspolitischer Maßnahmen beurteilen,</li> <li>• verstehen die wesentlichen Herausforderungen der modernen Geld- und Fiskalpolitik und können wirtschaftspolitische Entscheidungsprozesse modelltheoretisch abbilden,</li> <li>• sind mit den Grundlagen der Wachstumsökonomik vertraut und können das Solow-Modell zur Bewertung von langfristigen Zusammenhängen und der Analyse der Quellen des Wirtschaftswachstums heranziehen,</li> <li>• können Mithilfe verschiedener Modellrahmen makroökonomische Argumente nachvollziehen und selbständig analysieren.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Makroökonomik II (Vorlesung)</b> <i>Inhalte:</i> Die Vorlesung erweitert die makroökonomischen Grundmodelle der Vorlesung Makroökonomik I entlang drei Dimensionen. Einerseits wird die Annahme einer geschlossenen Volkswirtschaft gelockert und die makroökonomischen Prozesse um Außenhandel und Wechselkursdynamiken in einer offenen Volkswirtschaft erweitert. In diesem Kontext werden auch unterschiedliche Wechselkurssysteme diskutiert und die Auswirkungen wirtschaftspolitischer Interventionen analysiert. Des Weiteren werden ausgewählte wirtschaftspolitische Fragestellungen vertiefend analysiert, insbesondere die Interaktionen zwischen wirtschaftspolitischen Entscheidungsträgern und Wirtschaftsakteuren, sowie ausgewählte Fragestellungen der Fiskal- und Geldpolitik. Die Makroökonomik der langen Frist wird durch eine Einführung in die Wachstumstheorie analysiert, wobei insbesondere die Quellen volkswirtschaftlichen Wachstums modelltheoretisch dargestellt werden.	2 SWS
<b>Lehrveranstaltung: Makroökonomik II (Übung)</b> <i>Inhalte:</i> Im Rahmen der begleitenden Übung/Tutorium vertiefen die Studierenden die Kenntnisse aus der Vorlesung anhand ausgewählter theoretischer Fragestellungen und üben die eigenständige Anwendung von Modellen.	2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>	6 C
<b>Prüfungsanforderungen:</b>	

<ul style="list-style-type: none"> <li>• Nachweis von Kenntnissen über die systematische Erfassung der außenwirtschaftlichen Beziehungen einer Volkswirtschaft und von Kenntnissen über deren Bedeutung für die Analyse des gesamtwirtschaftlichen Gleichgewichts und wirtschaftspolitischer Maßnahmen,</li> <li>• Nachweis von Kenntnissen über verschiedene Wechselkurssysteme und deren Bedeutung für die Analyse des gesamtwirtschaftlichen Gleichgewichts und wirtschaftspolitischer Maßnahmen,</li> <li>• Nachweis von Kenntnissen über ausgewählte vertiefende Fragen der Fiskal- und Geldpolitik,</li> <li>• Nachweis von Kenntnissen des Grundmodells der Wachstumsökonomik und volkswirtschaftlicher Zusammenhänge in der langen Frist,</li> <li>• die Studierenden zeigen, dass sie in der Lage sind, mit verschiedenen gesamtwirtschaftlichen Modellen analytisch und grafisch zu arbeiten, die dahinterstehenden Annahmen zu reflektieren sowie die sich ergebenden Unterschiede hinsichtlich der Wirkung wirtschaftspolitischer Maßnahmen darstellen und kritisch würdigen zu können.</li> </ul>	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-OPH.0008 Makroökonomik I
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Tino Berger, Prof. Dr. Andreas Fuchs, Prof. Dr. Krisztina Kis-Katos, Dr. Katharina Werner
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0005: Grundlagen der internationalen Wirtschaftsbeziehungen</b> <i>English title: Foundations of International Economic Relations</i>	6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden: <ul style="list-style-type: none"> <li>• kennen verschiedene Ursachen für die Teilnahme eines Landes an der internationalen Arbeitsteilung,</li> <li>• können verschiedene Ursachen für den relativen Preisvorteil eines Landes theoretisch fundieren und deren wirtschaftspolitische Konsequenzen darstellen,</li> <li>• sind mit den Wohlfahrtswirkungen von Außenhandel vertraut und können deren gesellschaftlichen Folgen reflektieren,</li> <li>• kennen mögliche staatliche Instrumente zur Beeinflussung von Im- und Exporten und können die sich daraus ergebenden gesellschaftlichen Konsequenzen einzelstaatlich und weltwirtschaftlich bewerten,</li> <li>• sind mit den Voraussetzungen und den Motiven einer multinationalen Unternehmertätigkeit vertraut,</li> <li>• haben einen Überblick über die verschiedenen Erscheinungsformen von Devisenmärkten und den Motiven der dort handelnden Akteure und können die dabei bestehenden Zusammenhänge darstellen,</li> <li>• sind vertraut mit verschiedenen Determinanten von Wechselkursen und können deren Relevanz kritisch reflektieren,</li> <li>• verstehen die Auswirkungen von Wechselkursveränderungen für eine Volkswirtschaft,</li> <li>• sind vertraut mit verschiedenen Wechselkursregimen und deren spezifischen Eigenschaften.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Grundlagen der internationalen Wirtschaftsbeziehungen</b> (Vorlesung) <i>Inhalte:</i> Die Vorlesung besteht aus zwei Teilen. Teil 1 gibt einen Überblick über die Ursachen und die Folgen der internationalen Arbeitsteilung. Dabei werden verschiedene Theorien des Internationalen Handels analysiert und deren volkswirtschaftliche Konsequenzen dargestellt. Auch die Gründe für staatliche Interventionen in den Welthandel sowie deren ökonomische Konsequenzen werden analysiert. In Teil 2 werden die verschiedenen Erscheinungsformen von Devisenmärkten und die dort praktizierten Geschäfte untersucht und die Bestimmungsfaktoren von Wechselkursen diskutiert und theoretisch vertieft. Darüber hinaus wird die Validität der Theorien mittels empirischer Studien überprüft.	2 SWS
<b>Lehrveranstaltung: Grundlagen der internationalen Wirtschaftsbeziehungen</b> (Übung) <i>Inhalte:</i> Im Rahmen der begleitenden Übung vertiefen die Studierenden die Kenntnisse aus der Vorlesung anhand ausgewählter theoretischer Fragestellungen.	2 SWS

<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> Nachweis von: <ul style="list-style-type: none"> <li>• Kenntnissen der Gründe für die internationale Arbeitsteilung sowie über Theorien zur Bestimmung relativer Preisvorteile eines Landes und über die ökonomischen Folgen des Außenhandels,</li> <li>• Kenntnissen über die Erscheinungsformen von Devisenmärkten und die dort praktizierten Geschäfte sowie der Bestimmungsfaktoren von Wechselkursen.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-OPH.0007 Mikroökonomik I, B.WIWI-OPH.0008 Makroökonomik I	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Tino Berger Prof. Dr. Udo Kreickemeier	
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 6	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0006: Wachstum und Entwicklung</b> <i>English title: Economic Growth and Development</i>	6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Nach Abschluss dieses Moduls haben die Studierenden ein grundlegendes Verständnis für die Ursachen und Konsequenzen von langfristigem Wirtschaftswachstum bekommen. Sie machen sich mit den Standardmodellen der Wachstumstheorie vertraut, bewerten empirische Tests dieser, ziehen wirtschaftspolitische Implikationen und reflektieren diese kritisch.	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Wachstum und Entwicklung (Vorlesung)</b> <i>Inhalte:</i> 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
<b>Lehrveranstaltung: Wachstum und Entwicklung (Übung)</b> <i>Inhalte:</i> In der begleitenden Übung sollen die Studierenden anhand von Übungsaufgaben ihr Wissen zu den in der Vorlesung behandelten Themen vertiefen und erweitern.	2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>	6 C
<b>Prüfungsanforderungen:</b> Nachweis: <ul style="list-style-type: none"> <li>• fundierter Kenntnisse über die Ursachen und Konsequenzen langfristiger Einkommensunterschiede,</li> <li>• von grundlegendem Verständnis der behandelten Wachstumsmodelle,</li> <li>• von der Fähigkeit zum selbstständigen Lösen von Anwendungsbeispielen im Themenbereich der Vorlesung (theoretisch, graphisch und verbal).</li> </ul>	
<b>Zugangsvoraussetzungen:</b>	<b>Empfohlene Vorkenntnisse:</b>



keine	B.WIWI-OPH.0008 Makroökonomik I B.WIWI-OPH.0006 Statistik
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Holger Strulik Dr. Katharina Werner
<b>Angebotshäufigkeit:</b> jedes zweite Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0007: Einführung in die Ökonometrie</b> <i>English title: Introduction to Econometrics</i>		6 C 6 SWS
<b>Lernziele/Kompetenzen:</b> 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 96 Stunden
<b>Lehrveranstaltung: Einführung in die Ökonometrie (Vorlesung)</b> <i>Inhalte:</i> <ol style="list-style-type: none"> <li>1. Einführung in lineare multiple Regressionsmodelle, Modellspezifikation, KQ-Schätzung, Prognose und Modellselektion, Multikollinearität und partielle Regression.</li> <li>2. Lineares Regressionsmodell mit normalverteilten Störtermen, Maximum-Likelihood-Schätzung, Intervallschätzung, Hypothesentests</li> <li>3. Asymptotische Eigenschaften des KQ- und GLS Schätzers</li> <li>4. Lineares Regressionsmodell mit verallgemeinerter Kovarianzmatrix, Modelle mit autokorrelierten und heteroskedastischen Fehlertermen, Testen auf Autokorrelation und Heteroskedastizität.</li> </ol>		2 SWS
<b>Lehrveranstaltung: Einführung in die Ökonometrie (Übung)</b> <i>Inhalte:</i> 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
<b>Lehrveranstaltung: Einführung in die Ökonometrie (Tutorium)</b> <i>Inhalte:</i> 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
<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> Die Studierenden zeigen, dass sie einfache ökonometrische Konzepte verstanden haben. Darüber hinaus sind sie in der Lage, diese auf reale wirtschaftliche Fragestellungen anzuwenden.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-OPH.0002 Mathematik B.WIWI-OPH.0006 Statistik	

<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Helmut Herwartz
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 5
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0008: Geldtheorie und Geldpolitik</b> <i>English title: Money and International Finance</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Nach erfolgreicher Absolvierung der Veranstaltung sind Studierende in der Lage: <ul style="list-style-type: none"> <li>• grundlegende makroökonomische Zusammenhänge zwischen der Geldpolitik und der Realwirtschaft zu verstehen,</li> <li>• die Funktionen des Finanzsystems, die Bedeutung von Zinsen und der Kreditvergabe zu verstehen,</li> <li>• die Transmissionskanäle der Geldpolitik zu verstehen,</li> <li>• die klassischen und neueren Instrumente der Zentralbanken zur Durchführung der Geldpolitik zu analysieren,</li> <li>• die Besonderheiten der Geldpolitik in der Eurozone zu verstehen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Geldtheorie und Geldpolitik (Vorlesung)</b> <i>Inhalte:</i> <ol style="list-style-type: none"> <li>1. Finanzmärkte</li> <li>2. Finanzmarktinstitutionen</li> <li>3. Zentralbanken</li> <li>4. Geldtheorie</li> </ol>		2 SWS
<b>Lehrveranstaltung: Geldtheorie und Geldpolitik (Übung)</b> <i>Inhalte:</i> In den Übungen werden die Inhalte der Vorlesung anhand von Aufgaben wiederholt und vertieft.		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b> <b>Prüfungsvorleistungen:</b> Bis zu drei Einsendehausaufgaben; Länge jeweils bis zu drei maschinengeschriebenen Seiten (Bedingung zur Zulassung zur Klausur ist das Erreichen von 60% der insgesamt erreichbaren Punkte).		6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Nachweis fundierter Kenntnisse der Begriffe im Bereich der Geldtheorie und Geldpolitik durch intuitive und analytische Beantwortung von Fragen,</li> <li>• Nachweis der Fähigkeit zur grafischen und mathematischen Analyse der Geldtheorie und Geldpolitik.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-OPH.0008 Makroökonomik I	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Tino Berger	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b>	<b>Empfohlenes Fachsemester:</b>	

zweimalig	3 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0010: Einführung in die Institutionenökonomik</b> <i>English title: Foundations of Institutional Economics</i>	6 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden: <ul style="list-style-type: none"> <li>• kennen verschiedene Definitionen von internen und externen Institutionen, sowie deren Relevanz in der wirtschaftspolitischen Normsetzung,</li> <li>• kennen die Rolle von Eigentumsrechten und deren Durchsetzung in der ökonomischen Theorie und Praxis,</li> <li>• kennen Konzepte von Transaktionskosten und deren Wirkung auf die</li> <li>• Interaktion von Individuen und Firmen auf dem Markt,</li> <li>• kennen die Rolle des Staates bei der Einführung und Durchsetzung externer Institutionen,</li> <li>• kennen Grundlagen der Neuen Politischen Ökonomik und deren Theorie der Demokratie, Bürokratie und Interessengruppe,</li> <li>• kennen institutionenökonomische Analysekonzepte wie die Prinzipal-Agenten-Theorie oder Moral Hazard, sowie experimentelle Forschungsergebnisse zur Institutionenanalyse,</li> <li>• kennen die Rolle und den Wandel von Verhaltensmodellen als wirtschaftspolitisches Instrument.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden
<b>Lehrveranstaltung: Einführung in die Institutionenökonomik (Vorlesung)</b> <i>Inhalte:</i> Diese Vorlesung soll die theoretischen Grundlagen der Institutionenökonomik vermitteln und verschiedene (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 dienen 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	2 SWS

<p>der Zusammenhang von Institutionen mit wirtschaftlichem Wachstum und Entwicklung vermittelt.</p> <p>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.</p> <p>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.</p>		
<p><b>Prüfung: Klausur (90 Minuten)</b>  <b>Prüfungsvorleistungen:</b>                  Bearbeitung von zwei Hausaufgaben, von denen mindestens eine bestanden werden muss.</p>	6 C	
<p><b>Prüfungsanforderungen:</b>                  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.</p>		
<p><b>Zugangsvoraussetzungen:</b> keine</p>	<p><b>Empfohlene Vorkenntnisse:</b>                  B.WIWI-OPH.0007 Mikroökonomik I,                  B.WIWI-OPH.0008 Makroökonomik I</p>	
<p><b>Sprache:</b> Deutsch</p>	<p><b>Modulverantwortliche[r]:</b> Prof. Dr. Kilian Bizer</p>	
<p><b>Angebotshäufigkeit:</b> unregelmäßig</p>	<p><b>Dauer:</b> 1 Semester</p>	
<p><b>Wiederholbarkeit:</b> zweimalig</p>	<p><b>Empfohlenes Fachsemester:</b> 3 - 6</p>	
<p><b>Maximale Studierendenzahl:</b> nicht begrenzt</p>		

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-VWL.0059: Internationale Finanzmärkte</b> <i>English title: International Financial Markets</i>	6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Nach erfolgreicher Absolvierung der Veranstaltung sind Studenten in der Lage: <ul style="list-style-type: none"> <li>• grundlegende makroökonomische Zusammenhänge auf dem Devisenmarkt zu verstehen und intuitiv wiederzugeben,</li> <li>• das Zusammenspiel von verschiedenen Makrovariablen und ihre Wirkung auf den Wechselkurs zu verstehen,</li> <li>• optimale Investitionsentscheidungen der Investoren selbstständig zu ermitteln,</li> <li>• Bedingungen zu bewerten, unter denen Industrie- und Entwicklungsländer auf dem internationalen Finanzmarkt zusammenarbeiten.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Internationale Finanzmärkte (Vorlesung)</b> <i>Inhalte:</i> 1. Monetärer Ansatz auf lange Sicht Einfaches monetäres Modell. Die Art und Weise wie Preisanpassungen zu einem langfristigen Gleichgewicht führen. Realzins und Wechselkurs. 2. Asset-Ansatz auf kurze Sicht Kurzfristiges Gleichgewicht am Geldmarkt und am Devisenmarkt. Die Beziehung zwischen Inlandsrenditen, Auslandsrenditen und dem Wechselkurs einschließlich Überschreitung. 3. Zahlungsbilanz Bruttonationaleinkommen, Bruttoinlandsausgaben, Ersparnis und Investitionen in einer geschlossenen / offenen Wirtschaft. Leistungsbilanz und seine Komponenten. Globales Ungleichgewicht und reale Beispiele dafür. 4. Gewinne der finanziellen Globalisierung Das Konzept des externen Reichtums und wie man es berechnet. Die langfristige Budgetbeschränkung und ihre Anwendung für Industrie- und Schwellenländer. Konsumglättung, effiziente Investition, finanzielle Offenheit und Risikostreuung. 5. Fixe und flexible Wechselkurssysteme Feste Wechselkurse, Crawling Peg und flexible Wechselkurse: Vor- und Nachteile. Wirtschaftliche Ähnlichkeit und Kosten asymmetrischer Schocks. Kooperative und nicht kooperative Anpassungen der Zinssätze. 6. Währungsunionen Das Mundell-Fleming-Modell, Geld- und Fiskalpolitik. Die Theorie optimaler Währungsräume. Die Anwendung dieser Theorie auf die Eurozone und Zusammenhang mit der Eurokrise.	2 SWS
<b>Lehrveranstaltung: Internationale Finanzmärkte (Übung)</b> <i>Inhalte:</i>	2 SWS



In den Übungen werden die Inhalte der Vorlesung anhand von Aufgaben wiederholt und vertieft.	
<b>Prüfung: Klausur (90 Minuten)</b>	6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Nachweis fundierter Kenntnisse der Begriffe im Bereich der internationalen Finanzen durch intuitive und analytische Beantwortung von Fragen,</li> <li>• Nachweis der Fähigkeit zur mathematischen Herleitung der gewinnoptimierenden Entscheidung von hypothetischen Investoren oder Zentralbanken,</li> <li>• Nachweis der Fähigkeit zur grafischen und mathematischen Analyse der finanziellen Globalisierung.</li> </ul>	
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-OPH.0008 Makroökonomik I, B.WIWI-VWL.0005: Grundlagen der internationalen Wirtschaftsbeziehungen
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Tino Berger
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-WIN.0001: Management der Informationssysteme</b> <i>English title: Management of Business Information Systems</i>	6 C 3 SWS
<b>Lernziele/Kompetenzen:</b> Nach erfolgreicher Teilnahme sind die Studierenden in der Lage: <ul style="list-style-type: none"> <li>• die Phasen einer Anwendungssystementwicklung zu beschreiben sowie dortige Instrumente erläutern und anwenden zu können,</li> <li>• Vorgehensweisen, Ansätze und Werkzeuge zur Entwicklung von Anwendungssystemen zu beschreiben, gegenüberzustellen und vor dem Hintergrund gegebener Problemstellungen zu bewerten,</li> <li>• Elemente von Modellierungstechniken und Gestaltungsmöglichkeiten von Anwendungssystemen zu beschreiben und zu erläutern,</li> <li>• ausgewählte Methoden zur Modellierung von Anwendungssystemen selbstständig anwenden zu können,</li> <li>• Prinzipien der Anwendungssystementwicklung auf gegebene Problemstellungen transferieren zu können,</li> <li>• Modellierungsaufgaben im Themenfeld der Vorlesung eigenständig zu bearbeiten, zu reflektieren und konstruktiv zu bewerten.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 38 Stunden Selbststudium: 142 Stunden
<b>Lehrveranstaltung: Management der Informationssysteme (Vorlesung)</b> <i>Inhalte:</i> 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. <ul style="list-style-type: none"> <li>- Grundlagen der Systementwicklung             <ul style="list-style-type: none"> <li>• Herausforderungen bei der Einführung einer neuen Software</li> <li>• Vorgehensweisen zur Systementwicklung (z. B. Prototyping)</li> <li>• Grunds. Ansätze der Systementwicklung (z. B. Geschäftsprozessorientierter Ansatz)</li> </ul> </li> <li>- Planung- und Definitionsphase             <ul style="list-style-type: none"> <li>• Methoden zur Systemplanung (z. B. Portfolio-Analyse)</li> <li>• Methoden zur System-Wirtschaftlichkeitsberechnung (z. B. Kapitalwertmethode)</li> <li>• Lastenhefte</li> <li>• Pflichtenhefte</li> </ul> </li> <li>- Entwurfsphase             <ul style="list-style-type: none"> <li>• Geschäftsprozessmodell (z. B. Ereignisgesteuerte Prozessketten)</li> <li>• Funktionsmodell (z. B. Anwendungsfall-Diagramm)</li> <li>• Datenmodell (z. B. Entity-Relationship-Modell)</li> </ul> </li> </ul>	2 SWS

<ul style="list-style-type: none"> <li>• Objektmodell (z. B. Klassendiagramm)</li> <li>• Gestaltung der Benutzungsoberfläche (Prinzipien / Standards)</li> <li>• Datenbankmodelle</li> </ul> <p>- Implementierungsphase</p> <ul style="list-style-type: none"> <li>• Prinzipien des Programmierens</li> <li>• Arten von Programmiersprachen</li> <li>• Übersetzungsprogramme</li> <li>• Werkzeuge (z. B. Anwendungsserver)</li> </ul> <p>- Abnahme- und Einführungsphase</p> <ul style="list-style-type: none"> <li>• Qualitätssicherung (z. B. Systemtests)</li> <li>• Prinzipien der Systemeinführung</li> </ul> <p>- Wartungs- und Pflegephase</p> <ul style="list-style-type: none"> <li>• Wartungsaufgaben</li> <li>• Portfolio-Analyse</li> </ul>	
<p><b>Lehrveranstaltung: Management der Informationssysteme</b> (Tutorium)</p> <p><i>Inhalte:</i></p> <ul style="list-style-type: none"> <li>• Vorstellung des grundlegenden Funktionsumfangs ausgewählter Modellierungssoftware,</li> <li>• Einführung in die Grundlagen des Modellierens,</li> <li>• Tutorielle Begleitung bei der Bearbeitung von Fallstudien.</li> </ul>	1 SWS
<p><b>Prüfung: Klausur (90 Minuten)</b></p> <p><b>Prüfungsvorleistungen:</b></p> <p>Erfolgreiche Bearbeitung von drei Modellierungsfallstudien und Bewertung von Lösungen im Rahmen eines kollegialen Peer-Review-Verfahrens.</p>	6 C
<p><b>Prüfungsanforderungen:</b></p> <p>Die Studierenden weisen in der Modulprüfung nach, dass sie:</p> <ul style="list-style-type: none"> <li>• die in der Vorlesung vermittelten Aspekte der Anwendungssystementwicklung erläutern und beurteilen können,</li> <li>• Projekte zur Anwendungssystementwicklung in die vermittelten Phasen einordnen können,</li> <li>• Vorgehensweisen, Ansätze und Werkzeuge zur Entwicklung von Anwendungssystemen auf praktische Problemstellungen transferieren können,</li> <li>• komplexe Aufgabenstellungen mit Hilfe der vermittelten Inhalte analysieren und Lösungsansätze selbstständig aufzeigen können,</li> <li>• Vermittelte Methoden zur Modellierung von Anwendungssystemen notationskonform anwenden können und</li> <li>• in der Vorlesung vermittelten Ansätze auf vergleichbare Problemstellungen im Umfeld betrieblicher Anwendungssysteme übertragen können.</li> </ul>	
<p><b>Zugangsvoraussetzungen:</b></p> <p>keine</p>	<p><b>Empfohlene Vorkenntnisse:</b></p> <p>Modul B.WIWI-OPH.0003: Informations- und Kommunikationssysteme</p>

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<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Dr. Sebastian Hobert
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3 - 6
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> Im Wintersemester werden die Vorlesungsinhalte mittels Videos vermittelt.	

<b>Georg-August-Universität Göttingen</b> <b>Modul B.WIWI-WIN.0002: Management der Informationswirtschaft</b> <i>English title: Fundamentals of Information Management</i>		6 C 6 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden: <ul style="list-style-type: none"> <li>• kennen und verstehen strategische, operative und technische Aspekte des Informationsmanagements im Unternehmen,</li> <li>• kennen und verstehen verschiedene theoretische Modelle und Forschungsfelder des Informationsmanagements,</li> <li>• kennen und verstehen die Aufgaben des strategischen IT-Managements, der IT-Governance, des IT Controllings und des Sicherheits- sowie IT-Risk-Managements,</li> <li>• kennen und verstehen die Konzepte und Best-Practices im Informationsmanagement von Gastreferenten in deren Unternehmen,</li> <li>• analysieren und evaluieren Journal- und Konferenzbeiträge hinsichtlich wissenschaftlicher Fragestellungen,</li> <li>• analysieren und evaluieren praxisorientierte Fallstudien hinsichtlich des Beitrags des Informationsmanagements für den wirtschaftlichen Erfolg eines Unternehmens.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 84 Stunden Selbststudium: 96 Stunden
<b>Lehrveranstaltung: Management der Informationswirtschaft (Vorlesung)</b> <i>Inhalte:</i> <ul style="list-style-type: none"> <li>• Modelle des Informationsmanagements</li> <li>• Grundlagen der Informationswirtschaft</li> <li>• Strategisches IT-Management &amp; IT-Governance</li> <li>• IT-Organisation</li> <li>• Sicherheitsmanagement &amp; IT- Risk Management</li> <li>• Außenwirksame IS &amp; e-Commerce</li> <li>• IT-Performance Management</li> <li>• Umsetzung &amp; Betrieb, Green IT</li> <li>• Projektmanagement</li> <li>• Highlights / Q&amp;A</li> </ul>		2 SWS
<b>Lehrveranstaltung: Methodische Übung Management der Informationswirtschaft (Übung)</b>		2 SWS
<b>Lehrveranstaltung: Inhaltliche Übung Management der Informationswirtschaft (Übung)</b>		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b> <b>Prüfungsanforderungen:</b> Nachweis von Kenntnissen über Grundlagen der Informationswirtschaft.		6 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Orientierungsphase	
<b>Sprache:</b>	<b>Modulverantwortliche[r]:</b>	

Deutsch	Prof. Dr. Lutz M. Kolbe
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 3
<b>Maximale Studierendenzahl:</b> nicht begrenzt	
<b>Bemerkungen:</b> <b>Angebotshäufigkeit</b> 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.	

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Che.1311: Schwingungsspektroskopie und zwischenmolekulare Dynamik</b> <i>English title: Vibrational Spectroscopy and Intermolecular Dynamics</i>	6 C 4 SWS
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<b>Lernziele/Kompetenzen:</b> <ul style="list-style-type: none"> <li>Die Absolvent*innen 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.</li> <li>Insbesondere verstehen sie harmonische und anharmonische Kopplungen, Intensitätseffekte, fortgeschrittene Symmetrieaspekte und experimentelle Techniken der Schwingungsspektroskopie.</li> <li>Sie können zwischenmolekulare Wechselwirkungen beschreiben, die sich daraus ergebenden Potentialhyperflächen, Aggregatstrukturen und dynamischen Phänomene analysieren und experimentelle Methoden der Spektroskopie von Molekülaggagaten vergleichen.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
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<b>Lehrveranstaltung: Vorlesung mit Übung: Schwingungsspektroskopie und zwischenmolekulare Dynamik</b>	
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<b>Prüfung: Klausur (180 Minuten)</b>	6 C
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<b>Prüfungsanforderungen:</b> Erfassung und quantitative Lösung von exemplarischen Fragestellungen aus dem Forschungsgebiet mit begrenzten Hilfsmitteln in vorgegebener Zeit, mindestens 50% der Sollpunktzahl.	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Martin Suhm
<b>Angebotshäufigkeit:</b> i.d.Regel alle zwei jahre	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> dreimalig	<b>Empfohlenes Fachsemester:</b> 1 - 2
<b>Maximale Studierendenzahl:</b> 64	

<b>Bemerkungen:</b> Die aktive Teilnahme an den angebotenen Übungsstunden wird dringend empfohlen.
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<b>Georg-August-Universität Göttingen</b> <b>Modul M.Che.1313: Elektronische Spektroskopie und Reaktionsdynamik</b> <i>English title: Electronic Spectroscopy and Reaction Dynamics</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Absolvent*innen 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Vorlesung mit Übung: Elektronische Spektroskopie und Reaktionsdynamik</b>		
<b>Prüfung: Klausur (180 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> Erfassung und quantitative Lösung von exemplarischen Fragestellungen aus dem Forschungsgebiet mit begrenzten Hilfsmitteln in vorgegebener Zeit, mindestens 50% der Sollpunktzahl.		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Alec Wodtke	
<b>Angebotshäufigkeit:</b> i.d.Regel alle 2 Jahre	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> dreimalig	<b>Empfohlenes Fachsemester:</b> 1 - 2	
<b>Maximale Studierendenzahl:</b> 64		
<b>Bemerkungen:</b> Die aktive Teilnahme an den angebotenen Übungsstunden wird dringend empfohlen.		



<b>Georg-August-Universität Göttingen</b>		6 C 5 SWS
<b>Modul M.Che.1314: Biophysikalische Chemie</b> <i>English title: Biophysical Chemistry</i>		
<b>Lernziele/Kompetenzen:</b> Nach erfolgreichem Abschluss des Moduls ... <ul style="list-style-type: none"> <li>• sollen die Studierenden in der Lage sein, die wesentlichen physikochemischen Zusammenhänge biologischer Materie zu verstehen</li> <li>• die generellen Triebkräfte biologischer Reaktionen kennen</li> <li>• Spektroskopische Methoden zur Strukturbestimmung biologischer Makromoleküle verstehen und anwenden können</li> <li>• die Grundzüge moderner optischer Mikroskopie sowie der Sondenmikroskopie verstanden haben</li> <li>• die Mechanik und Dynamik biologischer Systeme ausgehend vom Einzelmolekül bis zur einzelnen Zelle erörtern können</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 70 Stunden Selbststudium: 110 Stunden
<b>Lehrveranstaltung: Vorlesung mit Übungen Biophysikalische Chemie</b>		5 SWS
<b>Prüfung: Klausur (180 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Übertragung genereller physikochemischer Prinzipien, wie zum Beispiel der Reaktionsdynamik, (statistischen) Thermodynamik und Quantentheorie auf die Beschreibung biologischer Phänomene</li> <li>• Beschreibung biologisch relevanter Wechselwirkungskräfte, stochastischer Prozesse wie Diffusion, physikalischer Biopolymer-Modelle, der Eigenschaften von Biomembranen und der Visikoelastizität von weicher Materie.</li> <li>• Kenntnisse der wesentlichen Methoden, wie z.B. UV-Vis, Circular dichroismus, Rasterkraftmikroskopie, optische Fallen, Fluoreszenz, und optische Mikroskopie.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Andreas Janshoff	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> dreimalig	<b>Empfohlenes Fachsemester:</b> 1 - 2	
<b>Maximale Studierendenzahl:</b> 64		

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module M.Che.1315: Chemical Dynamics at Surfaces</b>		4 WLH
<b>Learning outcome, core skills:</b> 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.		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Lecture Combined with Tutorial: Chemical Dynamics at Surfaces</b>		
<b>Examination: Written examination (180 minutes)</b>		6 C
<b>Examination requirements:</b> 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		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Alec Wodtke	
<b>Course frequency:</b> normally every 2 years	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> three times	<b>Recommended semester:</b> 1 - 2	
<b>Maximum number of students:</b> 64		
<b>Additional notes and regulations:</b> Active participation in provided tutorial is recommended.		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1112: Effiziente Algorithmen</b> <i>English title: Efficient Algorithms</i>		5 C 3 SWS
<b>Lernziele/Kompetenzen:</b> Erwerb fortgeschrittener Kenntnisse und Fähigkeiten zur Entwicklung und Analyse effizienter Algorithmen und zur Untersuchung der Komplexität von Problemen in unterschiedlichen Anwendungsbereichen.		<b>Arbeitsaufwand:</b> Präsenzzeit: 42 Stunden Selbststudium: 108 Stunden
<b>Lehrveranstaltung: Vorlesung/Übung</b> <i>Inhalte:</i> Zum Beispiel: Randomisierte und Approximationsalgorithmen, Graphalgorithmen, Onlinealgorithmen, Netzwerkalgorithmen, Neurocomputing, Pattern-Matching-Algorithmen.		3 SWS
<b>Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 25 Min.).</b> <b>Prüfungsanforderungen:</b> 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
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm, Prof. Dr. Anita Schöbel, Prof. Dr. Florentin Andreas Wörgötter)	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 30		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1141: Semistrukturierte Daten und XML</b> <i>English title: Semistructured Data and XML</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Semistrukturierte Daten und XML (Vorlesung, Übung)</b>		
<b>Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 25 Min.)</b> <b>Prüfungsanforderungen:</b> 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
<b>Zugangsvoraussetzungen:</b> Datenbanken	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Wolfgang May	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 100		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Inf.1151: Specialisation Softwareengineering: Data Science and Big Data Analytics</b>		5 C 3 WLH
<b>Learning outcome, core skills:</b> The students <ul style="list-style-type: none"> <li>• can define the terms data science, data scientist and big data, and acquire knowledge about the principle of data science and big data analytics</li> <li>• become acquainted with the life cycle of data science projects and know how the life cycle can be applied in practice</li> <li>• gain knowledge about a statistical and machine learning modelling system</li> <li>• gain knowledge about basic statistical tests and how to apply them</li> <li>• gain knowledge about clustering algorithms and how to apply them</li> <li>• gain knowledge about association rules and how to apply them</li> <li>• gain knowledge about regression techniques and how to apply them</li> <li>• gain knowledge about classification techniques and how to apply them</li> <li>• gain knowledge about text analysis techniques and how to apply them</li> <li>• gain knowledge about big data analytics with MapReduce</li> <li>• gain knowledge about advanced in-database analytics</li> </ul>		<b>Workload:</b> Attendance time: 42 h Self-study time: 108 h
<b>Course: Data Science and Big Data Analytics</b> (Lecture, Exercise)		3 WLH
<b>Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.)</b> <b>Examination prerequisites:</b> Successful completion of 50% of each exercise and the conduction of a small analysis project. <b>Examination requirements:</b> Data science, big data, analytics, data science life cycle, statistical tests, clustering, association rules, regression, classification, text analysis, in-database analytics.		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Foundations of statistics and stochastic.	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Jens Grabowski	
<b>Course frequency:</b> unregelmäßig	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>	
<b>Maximum number of students:</b> 30		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Inf.1171: Cloud and Service Computing</b>	5 C 3 WLH
<p><b>Learning outcome, core skills:</b>  Successfully completing the module, students understand</p> <ul style="list-style-type: none"> <li>• hybrid clouds, consisting of private and public clouds</li> <li>• basic web technologies (transfer protocols, markup languages, markup processing, RESTful and SOAP web services)</li> <li>• virtualization technologies (server, storage, and network virtualization)</li> <li>• data services (sharing, management, and analysis)</li> <li>• continuous integration/continuous delivery</li> <li>• container and orchestration in clouds (e.g. Kubernetes, OpenStack Heat)</li> <li>• monitoring of cloud infrastructures</li> <li>• interoperability in clouds (e.g. Helm)</li> <li>• portability and security</li> <li>• microservices</li> <li>• cloud computing workloads</li> </ul> <p>On completion of this module students will have a good understanding of the fundamental and up-to-date concepts used in the context cloud computing. This basic knowledge can be leveraged by students to design, implement, and manage service-oriented cloud infrastructures by themselves.</p>	<p><b>Workload:</b>  Attendance time:  42 h  Self-study time:  108 h</p>
<p><b>Course: Cloud and Service Computing</b> (Lecture, Exercise)  <i>Contents:</i>  Cloud Computing is a method of providing shared computing resources, such as applications, computing, storage, networking, development, and deployment platforms. In cloud computing these resources can be delivered as service to the user. Such Service-oriented infrastructures are the backbone of modern IT systems. They pool resources, enable collaboration between people, and provide complex services to end-users. Everybody who uses today's web applications implicitly relies on sophisticated service-oriented infrastructures. The same is true for users of mobile devices such as tablet computers and smart phones, which provide most of their benefits leveraging services.</p> <p>The key challenges of cloud computing infrastructures are related to scaling services. More specifically large cloud-computing infrastructures require scalability of IT management, programming models, and power consumption. The challenges to scale services lie in the inherent complexity of hardware, software, and the large amount of user requests, which large-scale services are expected to handle. This module teaches methods that address and solve those challenges in practice. Key aspects of the module are the management of IT infrastructures, the management of service landscapes, and programming models for distributed applications.</p> <p>The module covers the virtualization of computing, storage, and network resources as the fundament for scaling. IT management is covered by the discussion of deployment</p>	3 WLH

<p>models, service level agreements. Programming models are covered by discussing RESTful and SOAP web-services.</p> <p>Both, lectures and exercises, keep a close connection to the practical application of the discussed topics. The practical value of service-oriented infrastructures is highlighted in the context of enterprises as well as in the context of science. The methods taught in this module benefit from the lecturers' experiences at GWDG and thus provide exclusive insights into the topic. After successfully attending these modules students will understand the most important aspects to design, implement, and manage internet-scale cloud computing infrastructures.</p>	
<p><b>Examination: Written exam (90 min) or oral exam (approx. 30 min)</b></p> <p><b>Examination requirements:</b></p> <ul style="list-style-type: none"> <li>• Hybrid and Multi cloud infrastructures</li> <li>• RESTful and SOAP web services</li> <li>• Compute, storage, and network virtualisation</li> <li>• Infrastructure-as-a-service, platform-as-a-service, software-as-a-service</li> <li>• Characteristics of Cloud computing (NIST)</li> <li>• Service life cycle</li> <li>• Service level agreements</li> <li>• Cloud computing workloads (e.g. batch, SaaS, big data, back-end)</li> </ul>	5 C

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

<b>Georg-August-Universität Göttingen</b> <b>Module M.Inf.1172: Using Research Infrastructures</b>	5 C 3 WLH
<b>Learning outcome, core skills:</b> Successfully completing the module, students <ul style="list-style-type: none"> <li>• understand what methods and services are available in state-of-the-art research infrastructures and direction of future development</li> <li>• understand the infrastructures for eScience and eResearch</li> <li>• know basics of data management and data analysis</li> <li>• know the fundamental of technologies like cloud computing and grids</li> <li>• understand the real-world problems from different domains (e.g., high energy physics, humanities, medical science, etc.) which are tackled by research infrastructures</li> <li>• understand certain aspects, methods and tools of these infrastructures for different use cases from different domains</li> <li>• will be motivated to take part in other related modules (e.g., Specialization in Distributed Systems, Parallel Computing, etc.)</li> </ul>	<b>Workload:</b> Attendance time: 42 h Self-study time: 108 h
<b>Course: Using Research Infrastructures - Examples from Humanities and Sciences</b> (Lecture, Exercise) <i>Contents:</i> Successfully completing the lecture, students <ul style="list-style-type: none"> <li>• understand the role and importance of the research infrastructure and their general building blocks</li> <li>• know the basics of grid computing</li> <li>• know the basics of cloud computing</li> <li>• learn basics on system virtualization</li> <li>• learn fundamental ideas of data management and analysis</li> <li>• 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</li> <li>• understand certain aspects, methods and tools of these infrastructures for different use cases from different domains</li> <li>• will be motivated to take part in other related modules (e.g., Specialization in Distributed Systems, Parallel Computing, etc.)</li> <li>• 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</li> </ul>	3 WLH
<b>Examination: Written examination (90 minutes)</b> <b>Examination requirements:</b> 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



<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Ramin Yahyapour
<b>Course frequency:</b> unregelmäßig	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>
<b>Maximum number of students:</b> 30	

<b>Georg-August-Universität Göttingen</b>		5 C
<b>Module M.Inf.1185: Sensor Data Fusion</b>		4 WLH
<p><b>Learning outcome, core skills:</b></p> <p>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.</p> <p>After successful completion of the module, students are able to</p> <ul style="list-style-type: none"> <li>• define the notion of data fusion and distinguish different data fusion levels</li> <li>• formalize data fusion problems as state estimation problems</li> <li>• develop distributed and decentralized data fusion architectures</li> <li>• describe the basic concepts of linear estimation theory</li> <li>• explain the fundamental formulas for the fusion of noisy data</li> <li>• deal with unknown correlations in data fusion</li> <li>• understand the Bayesian approach to data fusion and estimation</li> <li>• formulate dynamic models for time-varying phenomena</li> <li>• describe the concept of a recursive Bayesian state estimator</li> <li>• explain and apply the Kalman filter for state estimation in dynamic systems</li> <li>• explain and apply basic nonlinear estimation techniques such as the Extended Kalman filter (EKF) and Unscented Kalman filter (UKF)</li> <li>• assess the properties, advantages, and disadvantages of the discussed (nonlinear) estimators</li> <li>• explain different approaches to deal with uncertainty such as probability theory, fuzzy theory, and Dempster–Shafer theory</li> <li>• identify data fusion applications and assess the benefits of data fusion</li> </ul>		<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 94 h</p>
<b>Course: Sensor Data Fusion</b> (Lecture, Exercise)		4 WLH
<p><b>Examination: Written exam (90 min.) or oral exam (approx. 20 min.)</b></p> <p><b>Examination requirements:</b></p> <p>Definition of data fusion; data fusion levels; formalization of data fusion problems; distributed and decentralized fusion architectures; linear estimation theory; fundamental fusion formulas; dynamic state estimation; Kalman filter; Extended Kalman filter (EKF); Unscented Kalman filter (UKF), algorithms for dealing with unknown correlations; fuzzy theory; Dempster-Shafer theory</p>		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Marcus Baum	
<b>Course frequency:</b> irregular	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>	

<b>Maximum number of students:</b>	
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50	
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<b>Georg-August-Universität Göttingen</b>		5 C
<b>Module M.Inf.1186: Seminar Hot Topics in Data Fusion and Analytics</b>		2 WLH
<b>Learning outcome, core skills:</b> After successful completion of the modul students are able to <ul style="list-style-type: none"> <li>• get acquainted with a specific research topic in the area of data fusion and data analytics</li> <li>• explain the considered problem in the chosen research topic</li> <li>• collect, evaluate, and summarize related work</li> <li>• describe solution approaches for the considered problem</li> <li>• discuss advantages and disadvantages of the proposed approaches</li> <li>• give an outlook to future research directions</li> <li>• prepare and give a presentation about the chosen research topic</li> <li>• write a scientific report about the chosen research topic</li> <li>• follow recent research in data fusion and data analytics</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 122 h
<b>Course: Hot Topics in Data Fusion and Analytics (Seminar)</b>		2 WLH
<b>Examination: Presentation (approx. 45 minutes) and written report (max. 20 pages)</b> <b>Examination prerequisites:</b> Attendance in 80% of the seminar presentations <b>Examination requirements:</b> Advanced knowledge of a specific research topic in the field of data fusion and data analytics; written scientific report; oral presentation		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Marcus Baum	
<b>Course frequency:</b> irregular	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>	
<b>Maximum number of students:</b> 15		

<b>Georg-August-Universität Göttingen</b>		5 C
<b>Module M.Inf.1188: Mobile Robotics</b>		4 WLH
<b>Learning outcome, core skills:</b> This module is concerned with fundamental principles and algorithms for mobile robot navigation and perception. After completion, the students are able to <ul style="list-style-type: none"> <li>• model the locomotion of wheeled mobile robots</li> <li>• understand the concept of dead reckoning</li> <li>• describe the most common sensors for mobile robots, e.g., inertial sensors and beam-based sensors</li> <li>• employ probabilistic state estimation methods such as Kalman filters and sequential Monte Carlo methods (particle filters) for robot navigation and perception</li> <li>• describe and distinguish different concepts for localization such as trilateration and triangulation</li> <li>• implement and evaluate basic algorithms for localization</li> <li>• understand the robot mapping problem and explain different map representations such as occupancy grids</li> <li>• describe the problem of Simultaneous Localization and Mapping (SLAM)</li> <li>• implement and evaluate basic algorithms for SLAM such as graph-based approaches and Rao-Blackwellized particle filters</li> <li>• implement and evaluate basic feature extraction methods such as Random Sample Consensus (RANSAC)</li> <li>• design basic planning algorithms for mobile robots using, e.g., a Markov Decision Process (MDP)</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 94 h
<b>Course: Mobile Robotics</b> (Lecture, Exercise)		4 WLH
<b>Examination: Written exam (90 min.) or oral exam (approx. 20 min.)</b> <b>Examination requirements:</b> Motion models for wheeled robots; dead reckoning; mobile robot sensors; Kalman filter; particle filter; localization concepts and algorithms; robot mapping; Simultaneous Localization and Mapping (SLAM); feature extraction methods; planning algorithms		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Marcus Baum	
<b>Course frequency:</b> irregular	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>	
<b>Maximum number of students:</b> not limited		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1210: Seminar Algorithmische Methoden und theoretische Konzepte</b> <i>English title: Seminar on Algorithmic Methods and Theoretical Concepts in Computer Science</i>		5 C 2 SWS
<b>Lernziele/Kompetenzen:</b> 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 122 Stunden
<b>Lehrveranstaltung: Algorithmische Methoden und theoretische Konzepte</b> (Seminar) <i>Inhalte:</i> Aktuelle Originalarbeiten aus dem Bereich der theoretischen Informatik und algorithmischer Methoden.		2 SWS
<b>Prüfung: Vortrag (ca. 45 Min.) mit schriftlicher Ausarbeitung (max. 10 Seiten)</b> <b>Prüfungsanforderungen:</b> 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.		5 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 14		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1211: Probabilistische Datenmodelle und ihre Anwendungen</b> <i>English title: Probabilistic Data Models and Applications</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> 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 Anwendungsbereichen (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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Vorlesungen, Übungen und Seminare zu den vorgenannten Themen</b>		
<b>Prüfung: Klausur (60 Min.) oder mündliche Prüfung (ca. 20 Min.)</b> <b>Prüfungsanforderungen:</b> 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
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 30		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1213: Algorithmisches Lernen und Mustererkennung</b> <i>English title: Algorithmic Learning and Pattern Recognition</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Es werden spezialisierte Kompetenzen im Bereich des algorithmischen Lernens und der Mustererkennung vermittelt. Verständnis der theoretischen Grundlagen und der Probleme bei praktischen Anwendungen.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Algorithmisches Lernen</b> (Vorlesung, Übung) <i>Inhalte:</i> Es werden die Grundlagen des Algorithmischen Lernens vermittelt, prinzipielle Schranken und Möglichkeiten aufgezeigt und einige spezielle Ansätze diskutiert wie z. B. Grundlagen des PAC-Lernens und des PAC-Lernens mit Rauschen auf der Klassifikation. Schlüsselbegriffe wie VC Dimension und Rademacher-Komplexität von Hypothesenklassen die es ermöglichen, sowohl Möglichkeiten als auch Grenzen der Lernbarkeit zu verstehen.		4 SWS
<b>Prüfung: Klausur (60 Min.) oder mündliche Prüfung (ca. 20 Min.)</b> <b>Prüfungsanforderungen:</b> Nachweis über den Erwerb spezialisierter anwendungsorientierter Kenntnisse und Kompetenzen aus dem Bereich des algorithmischen Lernens und der Mustererkennung.		6 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Stephan Waack (Prof. Dr. Carsten Damm)	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 30		



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul M.Inf.1216: Datenkompression und Informationstheorie</b></p> <p><i>English title: Data Compression and Information Theory</i></p>	<p>6 C 4 SWS</p>
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<p><b>Lernziele/Kompetenzen:</b> Die Studierenden</p> <ul style="list-style-type: none"> <li>• kennen den schematischen Aufbau von Kommunikationssystemen und verstehen ihre stochastischen/algorithmischen Beschreibungen</li> <li>• kennen die Grundbegriffe und Sätze der Shannonschen und der algorithmischen Informationstheorie und können sie in konkreten Situationen anwenden</li> <li>• kennen grundlegende verlustfreie Quellencodes (Huffman, Shannon, Lauflängen) und Erweiterungen sowie arithmetische Codes und können ihre Eignung in Anwendungssituationen bewerten</li> <li>• verstehen das Prinzip der Codeadaptionen und seine Implementierung anhand ausgewählter Codes</li> <li>• kennen allgemeine Entwurfsprinzipien für Quellencodes und verstehen ihre Umsetzung in konkreten Implementierungen</li> <li>• kennen die Schritte der verlustbehafteten Datenkompression und können ihre Leistungsparameter analysieren</li> <li>• kennen die Grundzüge der Ratenverzerrungstheorie und können sie in konkreten Situationen anwenden</li> <li>• kennen wichtige Beispiele verlustbehafteter Datenkompression, können sie analysieren und in Anwendungssituationen bewerten</li> </ul>	<p><b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden</p>
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<p><b>Lehrveranstaltung: Datenkompression und Informationstheorie (Vorlesung, Übung)</b></p>	<p>4 SWS</p>
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<p><b>Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.)</b></p> <p><b>Prüfungsvorleistungen:</b> Bearbeitung von 50% aller Übungsblätter, Vorführung mindestens einer Aufgabe während der Übung, kontinuierliche Teilnahme an den Übungen</p> <p><b>Prüfungsanforderungen:</b> In der Prüfung wird die aktive Beherrschung der vermittelten Inhalte und Techniken nachgewiesen, z.B.</p> <ul style="list-style-type: none"> <li>• Verständnis der Zusammenhänge durch Umschreibung in eigenen Worten nachweisen</li> <li>• Konstruktion von Codes nach Vorgabe stochastischer Parameter</li> <li>• Schätzung stochastischer Parameter von Quellen und Kanälen</li> <li>• begründete Auswahl von Codierungsverfahren in hypothetischer Anwendungssituation</li> <li>• Codeparameter, Kanalkapazität etc. berechnen</li> <li>• (teilweise) programmtechnische Umsetzung von Quellen (de-)codierern</li> <li>• modulare Beschreibung konkreter Kommunikationssysteme darlegen</li> <li>• Leistungsparameter konkreter Quellencodierverfahren analysieren</li> </ul>	<p>6 C</p>
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<p><b>Zugangsvoraussetzungen:</b></p>	<p><b>Empfohlene Vorkenntnisse:</b></p>
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keine	Beherrschung einer Programmiersprache
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Carsten Damm
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>
<b>Maximale Studierendenzahl:</b> 30	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Inf.1231: Specialisation in Distributed Systems</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b> Successfully completing the module, students</p> <ul style="list-style-type: none"> <li>• have in-depth knowledge about one specific topical area of distributed systems</li> <li>• understand the challenges of designing this specific part of a distributed system and integrating it into a larger infrastructure</li> <li>• understand the tasks to operate this specific part of a distributed system within a modern data centre</li> <li>• can apply their knowledge to evaluate application scenarios and make decisions regarding the applicability of certain technical solutions</li> </ul> <p>Examples for specific topics are distributed architectures or distributed data and information management.</p>	<p><b>Workload:</b> Attendance time: 56 h Self-study time: 124 h</p>
<p><b>Course: Distributed Storage and Information Management</b> (Lecture, Exercise)</p> <p><i>Contents:</i> Successfully completing the module, students</p> <ul style="list-style-type: none"> <li>• understand how data and information can be stored and managed</li> <li>• know the generic components of a modern data centre</li> <li>• understand how to protect data using RAID and what RAID level to apply to what problem</li> <li>• know about “intelligent” storage systems, including concepts like caching</li> <li>• understand various storage networking technologies like Fibre Channel, iSCSI, and FCoE</li> <li>• know about network-attached, object and unified storage</li> <li>• basically understand how to achieve business continuity of storage systems</li> <li>• understand the different backup and archiving technologies</li> <li>• understand data replication</li> <li>• have a basic understanding of storage virtualization</li> <li>• know how to manage and how to secure storage infrastructures</li> </ul> <p>Remark</p> <p>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.</p> <p>References</p> <p>S. Gnanasundaram, A. Shrivastava (eds.), Information Storage and Management, John Wiley &amp; Sons, 2012. ISBN:978-1-118-09483-9</p>	<p>4 WLH</p>
<p><b>Examination: Written exam (90 min.) or oral exam (ca. 20 min.)</b></p> <p><b>Examination prerequisites:</b> Solving and presenting at least one exercise (written solution and presentation), as well as active participation during the exercises.</p>	<p>6 C</p>

<b>Examination requirements:</b> 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	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> <ul style="list-style-type: none"> <li>• Computer architecture</li> <li>• Basic network protocols</li> <li>• Virtualisation techniques</li> </ul>
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Ramin Yahyapour (Dr. Philipp Wieder)
<b>Course frequency:</b> unregelmäßig	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>
<b>Maximum number of students:</b> 30	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Inf.1232: Parallel Computing</b></p>	<p>6 C  4 WLH</p>
<p><b>Learning outcome, core skills:</b>  Successfully completing the module, students are able to:</p> <ul style="list-style-type: none"> <li>• define and describe the benefit of parallel computing</li> <li>• specify the classification of parallel computers (Flynn classification)</li> <li>• analytically evaluate the performance of parallel computing approaches (scaling/performance models)</li> <li>• know the parallel hardware and performance improvement approaches (cache coherence, pipeline, etc.)</li> <li>• know the interconnects and networks and their role in parallel computing</li> <li>• understand and develop sample parallel programs using different paradigms and development environments (e.g., shared memory and distributed models)</li> <li>• expose to some applications of Parallel Computing through hands-on exercises</li> </ul>	<p><b>Workload:</b>  Attendance time:  56 h  Self-study time:  124 h</p>
<p><b>Course: Parallel Computing</b> (Lecture, Exercise)  <i>Contents:</i>  Successfully completing the lecture, students are able to:</p> <ul style="list-style-type: none"> <li>• define and describe the benefit of parallel computing and identify the role of software and hardware in parallel computing</li> <li>• specify the Flynn classification of parallel computers (SISD, SIMD, MIMD)</li> <li>• analytically evaluate the performance of parallel computing approaches (Scaling/Performance models)</li> <li>• understand the different architecture of parallel hardware and performance improvement approaches (e.g., caching and cache coherence issues, pipeline, etc.)</li> <li>• define Interconnects and networks for parallel computing</li> <li>• architecture of parallel computing (MPP, Vector, Shared memory, GPU, Many-Core, Clusters, Grid, Cloud)</li> <li>• design and develop parallel software using a systematic approach</li> <li>• parallel computing algorithms and development environments (i.e. shared memory and distributed memory parallel programming)</li> <li>• write parallel algorithms/programs using different paradigms and environments (e.g., POSIX Multi-threaded programming, OpenMP, MPI, OpenCL/CUDA, MapReduce, etc.)</li> <li>• get exposed to some applications of Parallel Computing through exercises</li> </ul> <p>References</p> <ul style="list-style-type: none"> <li>• An Introduction to Parallel Programming, Peter S. Pacheco, Morgan Kaufmann (MK), 2011, ISBN: 978-0-12-374260-5.</li> <li>• Designing and Building Parallel Programs, Ian Foster, Addison-Waesley, 1995, ISBN 0-201-57594-9 (Available online).</li> </ul>	<p>4 WLH</p>

<ul style="list-style-type: none"> <li>• Advanced Computer Architecture: Parallelism, Scalability, Programmability, Kai Hwang, Int. Edition, McGraw Hill, 1993, ISBN: 0-07-113342-9.</li> <li>• In addition to the mentioned text book, tutorial and survey papers will be distributed in some lectures as extra reading material.</li> </ul>	
<p><b>Examination: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.)</b></p> <p><b>Examination requirements:</b>  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)</p>	6 C
<p><b>Admission requirements:</b></p> <ul style="list-style-type: none"> <li>• Data structures and algorithms</li> <li>• Programming in C/C++</li> </ul>	<p><b>Recommended previous knowledge:</b></p> <ul style="list-style-type: none"> <li>• Computer architecture</li> <li>• Basic knowledge of computer networks and topologies</li> </ul>
<p><b>Language:</b> English</p>	<p><b>Person responsible for module:</b> Prof. Dr. Ramin Yahyapour</p>
<p><b>Course frequency:</b> unregelmäßig</p>	<p><b>Duration:</b> 1 semester[s]</p>
<p><b>Number of repeat examinations permitted:</b> twice</p>	<p><b>Recommended semester:</b></p>
<p><b>Maximum number of students:</b> 50</p>	

<b>Georg-August-Universität Göttingen</b>		5 C
<b>Module M.Inf.1244: Seminar on optimal transport</b>		2 WLH
<b>Learning outcome, core skills:</b> By using original references students will familiarize themselves with advanced aspects of optimal transport theory or its applications in modern data analysis and machine learning and present their findings to the other participants. <ul style="list-style-type: none"> <li>• read and understand original research papers or graduate-level textbooks</li> <li>• collect background material on a given topic and its context</li> <li>• order and prioritize this material for a presentation</li> <li>• prepare a structured presentation with a corresponding handout</li> <li>• give an accessible presentation</li> <li>• answer questions from the audience that may go slightly beyond the presentation material</li> <li>• leading and participating in a scientific discussion</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 122 h
<b>Course: Seminar on optimal transport (Seminar)</b>		2 WLH
<b>Examination: Presentation (approx. 45 min.), follow-up discussion, and handout (max. 5 pages)</b> <b>Examination requirements:</b> Advanced knowledge on a specific topic in optimal transport research; structured presentation; handout		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Lecture “Computational optimal transport” or some course on optimization are strongly recommended.	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Bernhard Schmitzer	
<b>Course frequency:</b> irregular	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b>	
<b>Maximum number of students:</b> 15		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1268: Informationstheorie</b> <i>English title: Information Theory</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden <ul style="list-style-type: none"> <li>• kennen die mathematische Grundlagen der Informationstheorie</li> <li>• beherrschen die grundlegenden Begriffe der Informationstheorie</li> <li>• beherrschen die zentralen Begriffe und Verfahren der Datenkompression</li> <li>• kennen grundlegende Begriffe und Aussagen zur Kanalkapazität</li> <li>• kennen grundlegende Begriffe und Aussagen zur Kolmogorov-Komplexität</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Elements of Information Theory</b> (Vorlesung, Übung)		4 SWS
<b>Prüfung: Klausur (90 Min.) oder mündliche Prüfung (ca. 20 Min.)</b> <b>Prüfungsvorleistungen:</b> Bearbeitung von 50% aller Übungsblätter, Vorführung mindestens einer Aufgabe während der Übung, kontinuierliche Teilnahme an den Übungen <b>Prüfungsanforderungen:</b> In der Prüfung wird die aktive Beherrschung der vermittelten Inhalte und Techniken nachgewiesen, z.B. <ul style="list-style-type: none"> <li>• Kenntnisse von Grundbegriffen wie Entropie, relative Entropie, wechselseitige Information</li> <li>• asymptotische Äquipartitionseigenschaft und Typtheorie</li> <li>• Entropierate stochastischer Prozesse</li> <li>• Grundlagen der Datenkompression einschließlich ihrer Bezüge zur Spieltheorie</li> <li>• Kanalkapazität und Kanalcodierungssatz</li> <li>• Grundbegriffe der Kolmogorov-Komplexität</li> </ul>		6 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Stephan Waack	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 30		



<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1802: Praktikum XML</b> <i>English title: Practical Course on XML</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden verfügen über vertiefte Kenntnisse und Erfahrungen mit Konzepten und 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, Web Services und weiteren Sprachen und Werkzeugen.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Praktikum XML (Praktikum)</b>		
<b>Prüfung: Praktische Prüfung (ca. 4 Übungs- und Programmieraufgaben) und mündliche Prüfung (ca. 20 Min.)</b> <b>Prüfungsanforderungen:</b> 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 der W3C-Standards.		6 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Wolfgang May	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 50		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.Inf.1806: Projektseminar Datenbanken und Informationssysteme</b> <i>English title: Seminar and Project Databases</i>		6 C 2 SWS
<b>Lernziele/Kompetenzen:</b> 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden
<b>Lehrveranstaltung: Projektseminar Datenbanken und Informationssysteme</b>		
<b>Prüfung: Vortrag (ca. 60 Min.) mit schriftlicher Ausarbeitung (max. 25 Seiten)</b> <b>Prüfungsanforderungen:</b> 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
<b>Zugangsvoraussetzungen:</b> Datenbanken	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b> Deutsch, Englisch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Wolfgang May	
<b>Angebotshäufigkeit:</b> unregelmäßig	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b>	
<b>Maximale Studierendenzahl:</b> 16		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Inf.1808: Practical Course on Parallel Computing</b>		6 C 4 WLH
<b>Learning outcome, core skills:</b> Successfully completing the module, students are able to: <ul style="list-style-type: none"> <li>• practically work with a cluster of computers (e.g., using a batch system)</li> <li>• practically utilize grid computing infrastructures and manage their jobs (e.g., Globus toolkit)</li> <li>• apply distributed memory architectures for parallelism through practical problem solving (MPI programming)</li> <li>• utilize shared memory architectures for parallelism (e.g., OpenMP and pthreads)</li> <li>• utilize heterogenous parallelism (e.g., OpenCL, CUDA and general GPU programming concepts)</li> <li>• utilize their previous knowledge in data structures and algorithms to solve problems using their devised (or enhanced) parallel algorithms</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Practical Course on Parallel Computing (Practical course)</b> <i>Contents:</i> 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
<b>Examination: Oral examination (approx. 20 minutes), not graded</b> <b>Examination requirements:</b> <ul style="list-style-type: none"> <li>• understand how to manage computing jobs using a cluster of computers or using grid computing facilities</li> <li>• understand the configuration of a PBS cluster through practical assignments</li> <li>• practically use LRM clusters and POVray examples</li> <li>• understand cluster computing related topics (error handling, performance management, security) in more depth and using hands-on experience and practically using Globus toolkit</li> <li>• design and implement solutions for parallel programs using distributed memory architectures (using MPI)</li> <li>• design and implement solutions for parallel programs using shared memory parallelism (using OpenMP, pthreads)</li> <li>• practically work with MapReduce programming framework and problem solving using MapReduce</li> <li>• practically work with heterogenous parallelism environment (GPGPU, OpenCL, CUDA, etc.)</li> </ul>		6 C
<b>Admission requirements:</b> <ul style="list-style-type: none"> <li>• Data structures and algorithms</li> <li>• Programming in C/C++</li> </ul>	<b>Recommended previous knowledge:</b> <ul style="list-style-type: none"> <li>• Parallel Computing</li> <li>• Computer architecture</li> <li>• Basic knowledge of computer networks</li> <li>• Basic know-how of computing clusters</li> </ul>	

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

<b>Georg-August-Universität Göttingen</b> <b>Module M.Inf.2102: Advanced Statistical Learning for Data Science</b>		6 C 4 WLH
<b>Learning outcome, core skills:</b> Students will <ul style="list-style-type: none"> <li>• learn concepts of advanced statistical methods and their scope of applications. These methods comprise the EM algorithm, Markov models, Hidden Markov Models, Markov chain Monte Carlo.</li> <li>• gain a solid understanding of ensemble learning algorithms. In particular, we will address additive tree approaches like boosting and Random Forest algorithms, as well as methods for ensemble optimization</li> <li>• learn strategies for model assessment and selection such as nested cross-validation, Monte Carlo validation, or permutation tests. Moreover, this will comprise measures of model quality and robustness.</li> <li>• acquire practical experience in the interpretation of machine learning models and learn required methods for feature selection, importance, stability, and robustness</li> <li>• learn techniques of statistical network inference, their implementation as well as their application to high-dimensional data.</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Advanced Statistical Learning for Data Science (Lecture)</b> Hastie, et al. Elements of Statistical Learning <a href="https://web.stanford.edu/~hastie/ElemStatLearn/">https://web.stanford.edu/~hastie/ElemStatLearn/</a> Bishop: Pattern Recognition and Machine Learning. <a href="https://cs.ugoe.de/prml">https://cs.ugoe.de/prml</a>		2 WLH
<b>Examination: Written exam (90 min) or oral exam (approx. 20 min)</b> <b>Examination prerequisites:</b> M.Inf.2102.Ex: At least 50% of homework exercises solved. <b>Examination requirements:</b> Knowledge of advanced statistical methods, ensemble learning, model assessment, and interpretation as well as statistical network inference. Evaluate their advantages and disadvantages and the ability to implement and interpret the results of these techniques.		6 C
<b>Course: Statistical Learning in Data Science Exercise (Exercise)</b>		2 WLH
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Basic knowledge of linear algebra and probability Completion of B.Inf.1236 Machine Learning or equivalent	
<b>Language:</b> English	<b>Person responsible for module:</b> Jun.-Prof. Dr. Anne Christin Hauschild Prof. Dr. Michael Altenbuchinger	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 3	

<b>Maximum number of students:</b>	
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not limited	
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<b>Georg-August-Universität Göttingen</b> <b>Module M.Inf.2201: Probabilistic Machine Learning</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> After successful completion of the module, students <ul style="list-style-type: none"> <li>• know the principles, paradigms, and challenges of probabilistic reasoning</li> <li>• apply basis principles and tools to perform probabilistic reasoning</li> <li>• manipulate distributions and densities of random variables</li> <li>• apply different methods for inference in probabilistic models (direct solving, sampling, variational inference, Laplace approximation)</li> <li>• apply latent variable models for given problems</li> <li>• perform inference in various forms of Gaussian models using closure properties of the Gaussian family</li> <li>• use graphical models to describe and reason about multivariate distributions of random variables</li> <li>• apply and implement learning algorithms in probabilistic models</li> <li>• can choose from a toolbox of basic algorithms for probabilistic inference on given problems</li> <li>• can implement and debug probabilistic algorithms and inference techniques</li> <li>• apply state of the art deep probabilistic models such as variational autoencoders or normalizing flows</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Probabilistic Machine Learning (Lecture)</b>		4 WLH
<b>Examination: Written examination (120 minutes)</b> <b>Examination requirements:</b> <ul style="list-style-type: none"> <li>• Ability to use principles and tools of probabilistic reasoning on given problems</li> <li>• Ability to extend and modify existing algorithms of probabilistic inference</li> <li>• Ability to diagnose problems in algorithms of probabilistic reasoning</li> <li>• Ability to mathematically derive results in probabilistic models</li> <li>• Ability to use graphical models to simplify problems of probabilistic reasoning</li> <li>• Knowledge of common models and algorithms of probabilistic inference (Gaussian, Bayesian logistic regression, autoencoders, normalizing flows, and others).</li> <li>• Knowledge of common sampling algorithms (importance sampling, MCMC)</li> </ul>		9 C
<b>Course: Probabilistic Machine Learning – Exercise (Exercise)</b> Bonus % for the final exam can be gathered by successfully solving exercise sheets and defending them to a tutor.		2 WLH
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> <ul style="list-style-type: none"> <li>• Basic knowledge of linear algebra</li> <li>• Basic knowledge of multivariate calculus</li> <li>• Python, in particular numpy</li> <li>• Basic knowledge of probability</li> </ul>	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Fabian Sinz	

	Dr. Johannes Söding
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 4
<b>Maximum number of students:</b> 50	
<b>Additional notes and regulations:</b> The course can be taken in parallel to B.Inf.1237 Deep Learning.	



<b>Georg-August-Universität Göttingen</b>		5 C
<b>Module M.Inf.2241: Current Topics in Machine Learning</b>		2 WLH
<b>Learning outcome, core skills:</b> After successful completion of the module, students <ul style="list-style-type: none"> <li>• have gained a deeper knowledge in specific topics within the field of machine learning</li> <li>• have improved their oral presentation skills</li> <li>• know how to methodically read and analyse scientific research papers</li> <li>• know how to write an analysis of a specific research field based on their analysis of state-of-the-art research</li> <li>• have improved their ability to work independently in a pre-defined context</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 122 h
<b>Course: Current Topics in Machine Learning (Seminar)</b>		2 WLH
<b>Examination: Oral presentation (approx. 30 min.) and term paper (max. 5000 words)</b> <b>Examination requirements:</b> Knowledge in a specific field of machine learning; ability to present the acquired knowledge in a both orally and in a written report.		5 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Inf.1236 Machine Learning B.Inf.1237 Deep Learning (the seminar can accompany lecture in the same term)	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Alexander Ecker	
<b>Course frequency:</b> irregular	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 4	
<b>Maximum number of students:</b> 15		

<b>Georg-August-Universität Göttingen</b>		10 C 4 WLH
<b>Module M.Mat.0731: Advanced practical course in scientific computing</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> After having successfully completed the module, students are familiar with the analysis of problems in the area "Scientific computing" arising in practice. They <ul style="list-style-type: none"> <li>• develop large programming projects doing individual or group work;</li> <li>• analyse complex data sets and process them;</li> <li>• use special numerical libraries;</li> <li>• are experienced with advanced methods for the numerical solution of applied problems;</li> <li>• are familiar with basic principles of modular and structured programming in the context of scientific computing.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students possess advanced practical experience in the area "Scientific computing". They will be able to <ul style="list-style-type: none"> <li>• identify mathematical problems in applied problems and convert them into a mathematical model;</li> <li>• implement numerical algorithms in a programming language or a user system;</li> <li>• structure complex programming tasks such that they can be efficiently done by group work.</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 244 h
<b>Course: Advanced practical course in scientific computing (Internship)</b>		4 WLH
<b>Examination: Term Papermax. 50 pages (not counted appendices), alternatively, presentation (appr. 30 minutes)</b> <b>Examination prerequisites:</b> Regular participation in the practical course		10 C
<b>Examination requirements:</b> <ul style="list-style-type: none"> <li>• analysis and systematisation of applied problems;</li> <li>• knowledge in special methods of optimisation;</li> <li>• good programming skills.</li> </ul>		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.2300 Proficiency in object oriented programming	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> winter or summer semester, on demand	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b>	<b>Recommended semester:</b>	

twice	Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b>		10 C 6 WLH
<b>Module M.Mat.0741: Advanced practical course in stochastics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> After having successfully completed the module, students have deepened and expanded their knowledge of a stochastic 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 <ul style="list-style-type: none"> <li>• autonomously implement and interpret more complex stochastic problems using suitable software;</li> <li>• autonomously write more complex programs using suitable software;</li> <li>• master some advanced methods of statistical data analysis and stochastic 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.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• handle practical problems with the aid of advanced stochastic methods and the suitable stochastic simulation and analysis software and present the obtained results well;</li> <li>• use advanced visualisation methods for statistical data (e. g. of spatial data);</li> <li>• apply different algorithms to the suitable stochastic problem.</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 216 h
<b>Course: Advanced practical course in stochastics</b> (Internship)		6 WLH
<b>Examination: Presentation (appr. 30 minutes) and term paper (max. 50 pages not counted appendices)</b> <b>Examination prerequisites:</b> Regular participation in the practical course		10 C
<b>Examination requirements:</b> Special knowledge in stochastics, especially mastery of complex stochastic simulation and analysis software as well as methods for data analysis		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.3140	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	

<b>Maximum number of students:</b>	
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not limited	
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<b>Additional notes and regulations:</b>
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<b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics
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<b>Georg-August-Universität Göttingen</b>		10 C (incl. key comp.: 10 C)
<b>Module M.Mat.0971: Internship</b>		
<b>Learning outcome, core skills:</b> 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.		<b>Workload:</b> Attendance time: 0 h Self-study time: 300 h
<b>Course: Examination colloquium</b> (Colloquium)		
<b>Examination: Presentation (appr. 20 minutes) and written report (max. 10 pages), not graded</b> <b>Examination prerequisites:</b> Certificate of the successful completion of the posed duties in accordance with the internship contract		10 C
<b>Examination requirements:</b> Successfully handling of the posed duties according to the internship contract between the student and the enterprise.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> each semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4; Promotion: 1 - 6	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers of the Unit Mathematics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.3110: Higher analysis</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most known examples of function and sequence spaces like spaces of continuous functions, <math>L_p</math>, <math>l_p</math> and Sobolev spaces on bounded and unbounded areas;</li> <li>• 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;</li> <li>• analyse the regularity of solutions of elliptical boundary value problems inside the domain in question and on its boundary;</li> <li>• use basic theorems of linear operators in Banach spaces, especially the Banach-Steinhaus theorem, the Hahn-Banach theorem and the open mapping theorem;</li> <li>• discuss weak convergence concepts and basic characteristics of dual and double-dual spaces;</li> <li>• are familiar with basic concepts of spectral theory and the spectral theorem for bounded, self-adjoint operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• formulate and analyse differential equations and other problems in the language of functional analysis;</li> <li>• identify and describe the relevance of characteristics of functional analysis like choice of a suitable function space, completeness, boundedness or compactness;</li> <li>• evaluate the influence of boundary conditions and function spaces for existence, uniqueness and stability of solutions of differential equations.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Functional analysis / Partial differential equations (Lecture)</b>	4 WLH
<b>Examination: Written examination (120 minutes)</b> <b>Examination prerequisites:</b> M.Mat.3110.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Functional analysis / Partial differential equations - exercise session (Exercise)</b>	2 WLH
<b>Examination requirements:</b>	

Proof of the advanced knowledge about functional analysis or partial differential equations		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.0021, B.Mat.0022, B.Mat.1100	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> each summer semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Bachelor: 4 - 6; Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b>		
<ul style="list-style-type: none"> <li>• <b>Instructor:</b> Lecturers at the Mathematical Institute or at the Institute of Numerical and Applied Mathematics</li> <li>• <b>Written examination:</b> 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.</li> <li>• <b>Exclusions:</b> The module "Higher analysis" cannot be completed by taking a lecture course that has already been accounted in the Bachelor's studies.</li> </ul>		



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.3130: Operations research</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> 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 <ul style="list-style-type: none"> <li>• are able to identify problems of operations research in application-oriented problems and formulate them as optimisation problems;</li> <li>• know methods for the modelling of application-oriented problems and are able to apply them;</li> <li>• evaluate the target function included in a model and the side conditions on the basis of their particular important characteristics;</li> <li>• analyse the complexity of the particular resulting optimisation problem;</li> <li>• are able to develop optimisation methods for the solution of a problem of operation research or adapt general methods to special problems;</li> <li>• 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;</li> <li>• 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;</li> <li>• interpret the found solutions for the underlying practical problem and evaluate the model and solution method on this basis.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• discuss basic concepts of the area "Operations research";</li> <li>• explain basic ideas of proof in the area "Operations research";</li> <li>• identify typical applications in the area "Operations research".</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course (Lecture)</b>		4 WLH
<b>Examination: Oral examination appr. 20 minutes, alternatively written examination, 120 minutes</b> <b>Examination prerequisites:</b> M.Mat.3130.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Successful proof of the acquired skills and competencies in the area "Operations research"		
<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>	

none	B.Mat.2310
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> once a year	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b>		9 C
<b>Module M.Mat.3140: Mathematical statistics</b>		6 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> After having successfully completed the module "Mathematical statistics", students are familiar with the basic concepts and methods of mathematical statistics. They <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely, amongst others via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• are familiar with basic statistical distribution models;</li> <li>• are familiar with references of mathematical statistics to other mathematical areas.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students have acquired basic competencies in mathematical statistics. They will be able to <ul style="list-style-type: none"> <li>• apply statistical ways of thinking as well as basic mathematical methods of statistics;</li> <li>• formulate statistical models mathematical precisely;</li> <li>• analyse practical statistical problems mathematically precisely with the learned methods.</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Written examination 120 minutes, alternatively, oral examination, appr. 20 minutes</b> <b>Examination prerequisites:</b> M.Mat.3140.Ue: Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Successful proof of the acquired skills and competencies in the area "Mathematical statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.1400	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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once a year	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4511: Specialisation in analytic number theory</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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</p> <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Analytic number theory";</li> <li>• prepare substantial ideas of proof in the area "Analytic number theory".</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Analytic number theory"		
<b>Admission requirements:</b>		<b>Recommended previous knowledge:</b>

none	B.Mat.3311
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3311 "Advances in analytic number theory"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4512: Specialisation in analysis of partial differential equations</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial differential equations;</li> <li>• use different theorems of function theory for solving partial differential equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial differential equations;</li> <li>• know the importance of partial differential equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Analysis of partial differential equations";</li> <li>• prepare substantial ideas of proof in the area "Analysis of partial differential equations".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p>	<p>9 C</p>

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Analysis of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3312
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3312 "Advances in analysis of partial differential equations"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4513: Specialisation in differential geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Differential geometry";</li> <li>• prepare substantial ideas of proof in the area "Differential geometry".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C
<p><b>Course: Exercise session (Exercise)</b></p>	2 WLH
<p><b>Examination requirements:</b></p>	

Proof of the acquisition of special skills and the mastery of special knowledge in the area "Differential geometry"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3313
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3313 "Advances in variational analysis"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	

<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute
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<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4514: Specialisation in algebraic topology</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Algebraic topology";</li> <li>• prepare substantial ideas of proof in the area "Algebraic topology".</li> </ul>	<p><b>Workload:</b>  Attendance time: 84 h  Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>9 C</p>

<b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3314	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3314 "Advances in algebraic topology"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4515: Specialisation in mathematical methods in physics</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, <math>C^*</math> algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> <p>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.</p> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Mathematical methods of physics";</li> <li>• prepare substantial ideas of proof in the area "Mathematical methods of physics".</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course</b> (Lecture)		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Mathematical methods in physics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3315	
<b>Language:</b>	<b>Person responsible for module:</b>	

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English	Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3315 "Advances in mathematical methods in physics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4521: Specialisation in algebraic geometry</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Algebraic geometry";</li> <li>• prepare substantial ideas of proof in the area "Algebraic geometry".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C

<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3321	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3321 "Advances in algebraic geometry"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4522: Specialisation in algebraic number theory</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>Z_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Algebraic number theory";</li> <li>• prepare substantial ideas of proof in the area "Algebraic number theory".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3322
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3322 "Advances in algebraic number theory"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4523: Specialisation in algebraic structures</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Algebraic structures";</li> <li>• prepare substantial ideas of proof in the area "Algebraic structures".</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b>  <b>Examination prerequisites:</b></p> <p>Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Algebraic structures"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3323	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3323 "Advances in algebraic structures"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4524: Specialisation in groups, geometry and dynamical systems</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Groups, geometry and dynamical systems";</li> <li>• prepare substantial ideas of proof in the area "Groups, geometry and dynamical systems".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<p><b>Examination: Oral examination (approx. 20 minutes)</b>  <b>Examination prerequisites:</b></p> <p>Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions</p>	9 C

<b>Course: Exercise session</b> (Exercise)		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Groups, geometry and dynamical systems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3324	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3324 "Advances in groups, geometry and dynamical systems"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4525: Specialisation in non-commutative geometry</b></p>	<p>9 C 6 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
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<ul style="list-style-type: none"> <li>• interpret these homological invariants geometrically and correlate them with each other;</li> <li>• abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Non-commutative geometry";</li> <li>• prepare substantial ideas of proof in the area "Non-commutative geometry".</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Non-commutative geometry"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3325
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3325 "Advances in non-commutative geometry"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4531: Specialisation in inverse problems</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Inverse problems";</li> <li>• prepare substantial ideas of proof in the area "Inverse problems".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p>	<p>9 C</p>

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Inverse problems"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3331
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3331 "Advances in inverse problems"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4532: Specialisation in approximation methods</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Approximation methods";</li> <li>• prepare substantial ideas of proof in the area "Approximation methods".</li> </ul>	<p><b>Workload:</b>  Attendance time: 84 h  Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b>  <b>Examination prerequisites:</b></p>	<p>9 C</p>

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Approximation methods"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3332
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3332 "Advances in approximation methods"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4533: Specialisation in numerical methods of partial differential equations</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Numerics of partial differential equations";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<ul style="list-style-type: none"> <li>prepare substantial ideas of proof in the area "Numerics of partial differential equations".</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Numerical methods of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3333
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3333 "Advances in numerical methods of partial differential equations"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4534: Specialisation in optimisation</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Optimisation";</li> <li>• prepare substantial proof ideas in the area "Optimisation".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3334
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3334 "Advances in optimisation"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4537: Specialisation in variational analysis</b>	9 C 6 WLH
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
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After having successfully completed the module, students will be able to	
<ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Variational analysis";</li> <li>• prepare substantial ideas of proof in the area "Variational analysis".</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Variational analysis"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3337
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3337 "Advances in variational analysis"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4538: Specialisation in image and geometry processing</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Image and geometry processing";</li> <li>• prepare substantial ideas of proof in the area "Image and geometry processing".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3338
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3338 "Advances in image and geometry processing"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4539: Specialisation in scientific computing / applied mathematics</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Scientific computing / applied mathematics";</li> <li>• prepare substantial ideas of proof in the area "Scientific computing / applied mathematics".</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Scientific computing / applied mathematics"	

<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3339
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3339 "Advances in scientific computing / applied mathematics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4541: Specialisation in applied and mathematical stochastics</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economicsciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Applied and mathematical stochastics";</li> <li>• prepare substantial ideas of proof in the area "Applied and mathematical stochastics".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h Self-study time: 186 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p>	<p>9 C</p>

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Applied and mathematical stochastics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3341
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3341 "Advances in applied and mathematical stochastics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4542: Specialisation in stochastic processes</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>

<ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Stochastic processes";</li> <li>• prepare substantial ideas of proof in the area "Stochastic processes".</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Stochastic processes"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3342
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3342 "Advances in stochastic processes"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4543: Specialisation in stochastic methods in econometrics</b>		9 C 6 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>The successful completion of modules of the cycle "Stochastic methods of econometrics" 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</p> <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Stochastic methods of econometrics";</li> <li>• prepare substantial ideas of proof in the area "Stochastic methods of econometrics".</li> </ul>		<b>Workload:</b> Attendance time: 84 h Self-study time: 186 h
<b>Course: Lecture course (Lecture)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		9 C
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Stochastic methods in econometrics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3343	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b> 1 semester[s]	

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Usually subsequent to the module B.Mat.3343 "Advances in stochastic methods in econometrics"	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4544: Specialisation in mathematical statistics</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Variational analysis";</li> <li>• prepare substantial ideas of proof in the area "Variational analysis".</li> </ul>	<p><b>Workload:</b>  Attendance time: 84 h  Self-study time: 186 h</p>
<p><b>Course: Lecture course</b> (Lecture)</p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b>  <b>Examination prerequisites:</b></p>	<p>9 C</p>

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Mathematical statistics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3344
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3344 "Advances in mathematical statistics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4545: Specialisation in statistical modelling and inference</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Statistical modelling and inference";</li> <li>• prepare substantial ideas of proof in the area "Statistical modelling and inference".</li> </ul>	<p><b>Workload:</b>            Attendance time:            84 h            Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b> <b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	9 C
<b>Course: Exercise session (Exercise)</b>	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Statistical modelling and inference"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3345

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<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3345 "Advances in statistical modelling and inference"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4546: Specialisation in multivariate statistics</b></p>	<p>9 C 6 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Multivariate statistics";</li> <li>• prepare substantial ideas of proof in the area "Multivariate statistics".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 84 h</p> <p>Self-study time: 186 h</p>
<p><b>Course: Lecture course</b> (Lecture)</p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p> <p><b>Examination prerequisites:</b></p>	<p>9 C</p>

Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions	
<b>Course: Exercise session</b> (Exercise)	2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Multivariate statistics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3346
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3346 "Advances in multivariate statistics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4547: Specialisation in statistical foundations of data science</b>	9 C 6 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• enhance concepts and methods for special problems and applications in the area "Statistical foundations of data science";</li> <li>• prepare substantial ideas of proof in the area "Statistical foundations of data science".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:            84 h</p> <p>Self-study time:            186 h</p>
<b>Course: Lecture course (Lecture)</b>	4 WLH

<b>Examination: Oral examination (approx. 20 minutes)</b>		9 C
<b>Examination prerequisites:</b> Achievement of at least 50% of the exercise points and presentation, twice, of solutions in the exercise sessions		
<b>Course: Exercise session (Exercise)</b>		2 WLH
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of special knowledge in the area "Statistical foundations of data science"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3347	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module B.Mat.3347 "Advances in statistical foundations of data science"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module M.Mat.4611: Aspects of analytic number theory</b>		4 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Analytic number theory";</li> <li>• carry out scientific work under supervision in the area "Analytic number theory".</li> </ul>		<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Analytic number theory"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3311	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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Usually subsequent to the module M.Mat.4511 "Specialisation in analytic number theory"	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4612: Aspects of analysis of partial differential equations</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalized functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial differential equations;</li> <li>• use different theorems of function theory for solving partial differential equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial differential equations;</li> <li>• know the importance of partial differential equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Analysis of partial differential equations";</li> <li>• carry out scientific work under supervision in the area "Analysis of partial differential equations".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h Self-study time: 124 h</p>
<p><b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>6 C</p>

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Analysis of partial differential equations"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3312	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4512 "Specialisation in analysis of partial differential equations"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b>	6 C
<b>Module M.Mat.4613: Aspects of differential geometry</b>	4 WLH

<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, areas and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Differential geometry";</li> <li>• carry out scientific work under supervision in the area "Differential geometry".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
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<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
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<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C
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<b>Examination requirements:</b>	
Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Differential geometry"	

<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>
none	B.Mat.3313

<b>Language:</b>	<b>Person responsible for module:</b>
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English	Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4513 "Specialisation in differential geometry"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4614: Aspects of algebraic topology</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic topology";</li> <li>• carry out scientific work under supervision in the area "Algebraic topology".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3314	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4514 "Specialisation in algebraic topology"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module M.Mat.4615: Aspects of mathematical methods in physics</b>		4 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, <math>C^*</math> algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> <p>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.</p> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Mathematical methods of physics";</li> <li>• carry out scientific work under supervision in the area "Mathematical methods of physics".</li> </ul>		<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b>		
Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Mathematical methods in physics"		
<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>	
none	B.Mat.3315	
<b>Language:</b>	<b>Person responsible for module:</b>	
English	Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	
	1 semester[s]	

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Usually subsequent to the module M.Mat.4515 "Specialisation in mathematical methods in physics"	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4621: Aspects of algebraic geometry</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic geometry";</li> <li>• carry out scientific work under supervision in the area "Algebraic geometry".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C
<p><b>Examination requirements:</b></p> <p>Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic geometry"</p>	

<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3321
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4521 "Specialisation in algebraic geometry"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4622: Aspects of algebraic number theory</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>\mathbb{Z}_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic number theory";</li> <li>• carry out scientific work under supervision in the area "Algebraic number theory".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

<b>Course:</b> Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH
<b>Examination:</b> Oral examination (approx. 20 minutes)	6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3322
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4522 "Specialisation in algebraic number theory"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4623: Aspects of algebraic structures</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic structures";</li> <li>• carry out scientific work under supervision in the area "Algebraic structures".</li> </ul>	<p><b>Workload:</b>  Attendance time: 56 h  Self-study time: 124 h</p>
<p><b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>6 C</p>
<p><b>Examination requirements:</b>  Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Algebraic structures"</p>	
<p><b>Admission requirements:</b></p>	<p><b>Recommended previous knowledge:</b></p>

none	B.Mat.3323
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4523 "Specialisation in Variational Analysis"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4624: Aspects of groups, geometry and dynamical systems</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Groups, geometry and dynamical systems";</li> <li>• carry out scientific work under supervision in the area "Groups, geometry and dynamical systems".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C
<b>Examination requirements:</b>	

Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Groups, geometry and dynamical systems"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3324
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4524 "Specialisation in groups, geometry and dynamical systems"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4625: Aspects of non-commutative geometry</b></p>	<p>6 C 4 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
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<ul style="list-style-type: none"> <li>• interpret these homological invariants geometrically and correlate them with each other;</li> <li>• abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Non-commutative geometry";</li> <li>• carry out scientific work under supervision in the area "Non-commutative geometry".</li> </ul>	
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C
<p><b>Examination requirements:</b></p> <p>Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Non-commutative geometry"</p>	
<p><b>Admission requirements:</b></p> <p>none</p>	<p><b>Recommended previous knowledge:</b></p> <p>B.Mat.3325</p>
<p><b>Language:</b></p> <p>English</p>	<p><b>Person responsible for module:</b></p> <p>Dean of studies</p>
<p><b>Course frequency:</b></p> <p>Usually subsequent to the module M.Mat.4525 "Specialisation in non-commutative geometry"</p>	<p><b>Duration:</b></p> <p>1 semester[s]</p>
<p><b>Number of repeat examinations permitted:</b></p> <p>twice</p>	<p><b>Recommended semester:</b></p> <p>Master: 1 - 3</p>
<p><b>Maximum number of students:</b></p> <p>not limited</p>	
<p><b>Additional notes and regulations:</b></p> <p><b>Instructor:</b> Lecturers at the Mathematical Institute</p>	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4631: Aspects of inverse problems</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Inverse problems";</li> <li>• carry out scientific work under supervision in the area "Inverse problems".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<p><b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>6 C</p>

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Inverse problems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3331	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4531 "Specialisation in inverse problems"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4632: Aspects of approximation methods</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Approximation methods";</li> <li>• carry out scientific work under supervision in the area "Approximation methods".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<p><b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>6 C</p>

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Approximation methods"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3332	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4532 "Specialisation in approximation methods"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4633: Aspects of numerical methods of partial differential equations</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Numerics of partial differential equations";</li> </ul>	<p><b>Workload:</b>          Attendance time:          56 h          Self-study time:          124 h</p>

<ul style="list-style-type: none"> <li>carry out scientific work under supervision in the area "Numerics of partial differential equations".</li> </ul>	
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Numerical methods of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3333
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4533 "Specialisation in numerical methods of partial differential equations"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4634: Aspects of optimisation</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Optimisation";</li> <li>• carry out scientific work under supervision in the area "Optimisation".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

<b>Course:</b> Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH
<b>Examination:</b> Oral examination (approx. 20 minutes)	6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3334
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4534 "Specialisation in optimisation"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4637: Aspects of variational analysis</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

After having successfully completed the module, students will be able to		
<ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Variational analysis";</li> <li>• carry out scientific work under supervision in the area "Variational analysis".</li> </ul>		
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Variational analysis".		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3337	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4537 "Specialisation in Variational Analysis"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4638: Aspects of image and geometry processing</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Image and geometry processing";</li> <li>• carry out scientific work under supervision in the area "Image and geometry processing".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3338
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4538 "Specialisation in image and geometry processing"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4639: Aspects of scientific computing / applied mathematics</b>		6 C 4 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Scientific computing / Applied mathematics";</li> <li>• carry out scientific work under supervision in the area "Scientific computing / Applied mathematics".</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Scientific computing / applied mathematics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3339	
<b>Language:</b>	<b>Person responsible for module:</b>	

English	Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4539 "Specialisation in scientific computing / applied mathematics"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4641: Aspects of applied and mathematical stochastics</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Applied and mathematical stochastics";</li> <li>• carry out scientific work under supervision in the area "Applied and mathematical stochastics".</li> </ul>	<p><b>Workload:</b>          Attendance time:          56 h          Self-study time:          124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>	4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	6 C

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Applied and mathematical stochastics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3341	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4541 "Specialisation in applied and mathematical stochastics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4642: Aspects of stochastic processes</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Stochastic processes";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

<ul style="list-style-type: none"> <li>• carry out scientific work under supervision in the area "Stochastic processes".</li> </ul>		
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Stochastic processes"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3342	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4542 "Specialisation in stochastic processes"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		6 C 4 WLH
<b>Module M.Mat.4643: Aspects of stochastics methods of econometrics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>The successful completion of modules of the cycle "Stochastic methods of econometrics" 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</p> <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Stochastic methods of econometrics";</li> <li>• carry out scientific work under supervision in the area "Stochastic methods of econometrics".</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Stochastics methods of econometrics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3343	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4543 "Specialisation in stochastics methods of econometrics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	

<b>Maximum number of students:</b>	
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not limited	
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<b>Additional notes and regulations:</b>
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<b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics
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<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4644: Aspects of mathematical statistics</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Mathematical statistics";</li> <li>• carry out scientific work under supervision in the area "Mathematical statistics".</li> </ul>	<p><b>Workload:</b>  Attendance time: 56 h  Self-study time: 124 h</p>
<p><b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>6 C</p>

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Mathematical statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3344	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4544 "Specialisation in mathematical statistics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		6 C 4 WLH
<b>Module M.Mat.4645: Aspects of statistical modelling and inference</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Statistical modelling and inference";</li> <li>• carry out scientific work under supervision in the area "Statistical modelling and inference".</li> </ul>		<p><b>Workload:</b> Attendance time: 56 h Self-study time: 124 h</p>
<b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b>		4 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Statistical modelling and inference"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3345	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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Usually subsequent to the module M.Mat.4545 "Specialisation in statistical modelling and inference"	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4646: Aspects of multivariate statistics</b></p>	<p>6 C 4 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Multivariate statistics";</li> <li>• carry out scientific work under supervision in the area "Multivariate statistics".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<p><b>Course: Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)</b></p>	<p>4 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>6 C</p>

<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Multivariate statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4546	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4546 "Specialisation in multivariate statistics"	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4647: Aspects of statistical foundations of data science</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Statistical foundations of data science";</li> <li>• carry out scientific work under supervision in the area "Statistical foundations of data science".</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>

<b>Course:</b> Lecture course (4 WLH); alternatively lecture course (2 WLH) with exercises/seminar (2 WLH)	4 WLH
<b>Examination:</b> Oral examination (approx. 20 minutes)	6 C
<b>Examination requirements:</b> Proof of the acquisition of special skills and the mastery of advanced competencies in the area "Statistical foundations of data science"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4547
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> Usually subsequent to the module M.Mat.4547 "Specialisation in statistical foundations of data science"	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4711: Special course in analytic number theory</b>		3 C 2 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> 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 <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Analytic number theory";</li> <li>• become acquainted with special problems in the area "Analytic number theory" to carry out scientific work for it.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Lecture course (Lecture)</b>		2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Analytic number theory"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3311	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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not specified	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4712: Special course in analysis of partial differential equations</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial differential equations;</li> <li>• use different theorems of function theory for solving partial differential equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial differential equations;</li> <li>• know the importance of partial differential equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Analysis of partial differential equations";</li> <li>• become acquainted with special problems in the area "Analysis of partial differential equations" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b>  Attendance time:  28 h  Self-study time:  62 h</p>
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b>	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Analysis of partial differential equations"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3312
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<b>Georg-August-Universität Göttingen</b>		3 C
<b>Module M.Mat.4713: Special course in differential geometry</b>		2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Differential geometry";</li> <li>• become acquainted with special problems in the area "Differential geometry" to carry out scientific work for it.</li> </ul>		<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Lecture course (Lecture)</b>		2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		3 C
<b>Examination requirements:</b>		
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Differential geometry"		
<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>	
none	B.Mat.3313	

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<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4714: Special course in algebraic topology</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic topology";</li> <li>• become acquainted with special problems in the area "Algebraic topology" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C

<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3314	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4715: Special course in mathematical methods in physics</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, <math>C^*</math> algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> <p>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.</p> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Mathematical methods of physics";</li> <li>• become acquainted with special problems in the area "Mathematical methods of physics" to carry out scientific work for it.</li> </ul>		<p><b>Workload:</b> Attendance time: 28 h Self-study time: 62 h</p>
<b>Course: Lecture course (Lecture)</b>		2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Mathematical methods in physics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3315	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	

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<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4721: Special course in algebraic geometry</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic geometry";</li> <li>• become acquainted with special problems in the area "Algebraic geometry" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b>  Attendance time: 28 h  Self-study time: 62 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>3 C</p>
<p><b>Examination requirements:</b>  Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic geometry"</p>	

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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3321
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4722: Special course in algebraic number theory</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>\mathbb{Z}_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic number theory";</li> <li>• become acquainted with special problems in the area "Algebraic number theory" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>

<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3322
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4723: Special course in algebraic structures</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Algebraic structures";</li> <li>• become acquainted with special problems in the area "Algebraic structures" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<p><b>Examination requirements:</b></p> <p>Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Algebraic structures"</p>	

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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3323
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4724: Special course in groups, geometry and dynamical systems</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Groups, geometry and dynamical systems";</li> <li>• become acquainted with special problems in the area "Groups, geometry and dynamical systems" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Groups, geometry and dynamical systems"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3324
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4725: Special course in non-commutative geometry</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>

<ul style="list-style-type: none"> <li>• interpret these homological invariants geometrically and correlate them with each other;</li> <li>• abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Non-commutative geometry";</li> <li>• become acquainted with special problems in the area "Non-commutative geometry" to carry out scientific work for it.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<p><b>Examination requirements:</b></p> <p>Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Non-commutative geometry"</p>	
<p><b>Admission requirements:</b></p> <p>none</p>	<p><b>Recommended previous knowledge:</b></p> <p>B.Mat.3325</p>
<p><b>Language:</b></p> <p>English</p>	<p><b>Person responsible for module:</b></p> <p>Dean of studies</p>
<p><b>Course frequency:</b></p> <p>not specified</p>	<p><b>Duration:</b></p> <p>1 semester[s]</p>
<p><b>Number of repeat examinations permitted:</b></p> <p>twice</p>	<p><b>Recommended semester:</b></p> <p>Master: 1 - 3</p>
<p><b>Maximum number of students:</b></p> <p>not limited</p>	
<p><b>Additional notes and regulations:</b></p> <p><b>Instructor:</b> Lecturers at the Mathematical Institute</p>	



<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4731: Special course in inverse problems</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Inverse problems";</li> <li>• become acquainted with special problems in the area "Inverse problems" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Inverse problems"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3331
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4732: Special course in approximation methods</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Approximation methods";</li> <li>• become acquainted with special problems in the area "Approximation methods" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C

<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Approximation methods"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3332	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4733: Special course in numerical methods of partial differential equations</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Variational analysis";</li> <li>• become acquainted with special problems in the area "Variational analysis" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h  Self-study time:  62 h</p>

<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area Numerical methods of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3333
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4734: Special course in optimisation</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Optimisation";</li> <li>• become acquainted with special problems in the area "Optimisation" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3334
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> on an irregular basis	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4737: Special course in variational analysis</b>	3 C 2 WLH
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<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time:                  28 h</p> <p>Self-study time:                  62 h</p>
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After having successfully completed the module, students will be able to	
<ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Variational analysis";</li> <li>• become acquainted with special problems in the area "Variational analysis" to carry out scientific work for it.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b>	
Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Variational analysis"	
<b>Admission requirements:</b>	<b>Recommended previous knowledge:</b>
none	B.Mat.3337
<b>Language:</b>	<b>Person responsible for module:</b>
English	Dean of studies
<b>Course frequency:</b>	<b>Duration:</b>
not specified	1 semester[s]
<b>Number of repeat examinations permitted:</b>	<b>Recommended semester:</b>
twice	Master: 1 - 3
<b>Maximum number of students:</b>	
not limited	
<b>Additional notes and regulations:</b>	
<b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4738: Special course in image and geometry processing</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Image and geometry processing";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<ul style="list-style-type: none"> <li>• become acquainted with special problems in the area "Image and geometry processing" to carry out scientific work for it.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3338
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4739: Special course in scientific computing / applied mathematics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Scientific computing / applied mathematics";</li> <li>• become acquainted with special problems in the area "Scientific computing / applied mathematics" to carry out scientific work for it.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Lecture course (Lecture)</b>		2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>		3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Scientific computing / applied mathematics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3339	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	

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<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4741: Special course in applied and mathematical stochastics</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Applied and mathematical stochastics";</li> <li>• become acquainted with special problems in the area "Applied and mathematical stochastics" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Applied and mathematical stochastics"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3341
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Statistics	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4742: Special course in stochastic processes</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Stochastic processes";</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<ul style="list-style-type: none"> <li>• become acquainted with special problems in the area "Stochastic processes" to carry out scientific work for it.</li> </ul>	
<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Stochastic processes"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3342
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Statistics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4743: Special course in stochastic methods of econometrics</b>	3 C 2 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> The successful completion of modules of the cycle "Stochastic methods of econometrics" 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 <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Stochastic methods of econometrics";</li> <li>• become acquainted with special problems in the area "Stochastic methods of econometrics" to carry out scientific work for it.</li> </ul>	<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Stochastic methods of econometrics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3343
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b>	

**Instructor:** Lecturers at the Institute of Mathematical Statistics

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4744: Special course in mathematical statistics</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Mathematical statistics";</li> <li>• become acquainted with special problems in the area "Mathematical statistics" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C

<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Mathematical statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3344	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Statistics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4745: Special course in statistical modelling and inference</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Statistical modelling and inference";</li> <li>• become acquainted with special problems in the area "Statistical modelling and inference" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b>  Attendance time:  28 h  Self-study time:  62 h</p>
<b>Course: Lecture course (Lecture)</b>	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<p><b>Examination requirements:</b>  Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Statistical modelling and inference"</p>	
<p><b>Admission requirements:</b>  none</p>	<p><b>Recommended previous knowledge:</b>  B.Mat.3345</p>
<p><b>Language:</b>  English</p>	<p><b>Person responsible for module:</b>  Dean of studies</p>
<p><b>Course frequency:</b></p>	<p><b>Duration:</b></p>

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not specified	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Statistics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4746: Special course in multivariate statistics</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Multivariate statistics";</li> <li>• become acquainted with special problems in the area "Multivariate statistics" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<p><b>Course: Lecture course (Lecture)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral examination (approx. 20 minutes)</b></p>	<p>3 C</p>

<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Multivariate statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3346	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Statistics		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4747: Special course in statistical foundations of data science</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• conduct scholarly debates about problems of the area "Statistical foundations of data science";</li> <li>• become acquainted with special problems in the area "Statistical foundations of data science" to carry out scientific work for it.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h  Self-study time:  62 h</p>

<b>Course: Lecture course</b> (Lecture)	2 WLH
<b>Examination: Oral examination (approx. 20 minutes)</b>	3 C
<b>Examination requirements:</b> Proof of the acquisition of further special skills and the mastery of advanced competencies in the area "Statistical foundations of data science"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3347
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Statistics	

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4811: Seminar on analytic number theory</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Analytic number theory" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>		<p><b>Workload:</b> Attendance time: 28 h Self-study time: 62 h</p>
<b>Course: Seminar</b> (Seminar)		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>		3 C
<b>Examination prerequisites:</b> Participation in the seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Analytic number theory"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3311	
<b>Language:</b>	<b>Person responsible for module:</b>	

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English	Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4812: Seminar on analysis of partial differential equations</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial differential equations;</li> <li>• use different theorems of function theory for solving partial differential equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial differential equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial differential equations;</li> <li>• know the importance of partial differential equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Analysis of partial differential equations" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>  Attendance time:  28 h  Self-study time:  62 h</p>
<b>Course: Seminar (Seminar)</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C

<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Analysis of partial differential equations"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3312	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4813: Seminar on differential geometry</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Differential geometry" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Seminar (Seminar)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b>                  Participation in the seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b>                  Autonomous permeation and presentation of complex mathematical issues in the area "Differential geometry"</p>	
<p><b>Admission requirements:</b></p>	<p><b>Recommended previous knowledge:</b></p>

none	B.Mat.3313
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4814: Seminar on algebraic topology</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Algebraic topology" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>	3 C

<b>Examination prerequisites:</b> Participation in the seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3314	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4815: Seminar on mathematical methods in physics</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, <math>C^*</math> algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> <p>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.</p> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Mathematical methods of physics" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>		<p><b>Workload:</b> Attendance time: 28 h Self-study time: 62 h</p>
<b>Course: Seminar</b> (Seminar)		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>		3 C
<b>Examination prerequisites:</b> Participation in the seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Mathematical methods in physics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3315	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	

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<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4821: Seminar on algebraic geometry</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Algebraic geometry" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Seminar</b> (Seminar)</p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b>                  Participation in the seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic geometry"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3321	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4822: Seminar on algebraic number theory</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>Z_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Variational analysis" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3322
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4823: Seminar on algebraic structures</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Algebraic structures" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Seminar (Seminar)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b>                  Participation in the seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Autonomous permeation and presentation of complex mathematical issues in the area "Algebraic structures"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3323
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4824: Seminar on groups, geometry and dynamical systems</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Groups, geometry and dynamical systems" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<p><b>Course: Seminar</b> (Seminar)</p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p> <p><b>Examination prerequisites:</b> Participation in the seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Autonomous permeation and presentation of complex mathematical issues in the area "Groups, geometry and dynamical systems"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3324
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4825: Seminar on non-commutative geometry</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>

<ul style="list-style-type: none"> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> <li>• interpret these homological invariants geometrically and correlate them with each other;</li> <li>• abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Non-commutative geometry" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	
<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Non-commutative geometry"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3325
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4831: Seminar on inverse problems</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Inverse problems" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Seminar (Seminar)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b></p>	<p>3 C</p>

Participation in the seminar	
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Inverse problems"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3331
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4832: Seminar on approximation methods</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Approximation methods" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Seminar (Seminar)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b></p>	<p>3 C</p>

Participation in the seminar	
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Approximation methods"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3332
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4833: Seminar on numerical methods of partial differential equations</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Numerics of partial differential equations" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h  Self-study time:  62 h</p>

<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Numerical methods of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3333
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4834: Seminar on optimisation</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Optimisation" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3334
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4837: Seminar on variational analysis</b></p>	<p>3 C 2 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
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After having successfully completed the module, students will be able to	
<ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Variational analysis" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	
<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Variational analysis"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3337
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> Instructor: Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4838: Seminar on image and geometry processing</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Image and geometry processing" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3338
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4839: Seminar on scientific computing / applied mathematics</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Scientific computing / applied mathematics" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Seminar</b> (Seminar)		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar		3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Scientific computing / applied mathematics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3339	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	

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<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4841: Seminar on applied and mathematical stochastics</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Applied and mathematical stochastics" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Seminar (Seminar)</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Participation in the seminar</p>	<p>3 C</p>

<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Applied and mathematical stochastics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3341	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4842: Seminar on stochastic processes</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Variational analysis" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	
<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Stochastic processes"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3342
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4843: Seminar on stochastic methods of econometrics</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>The successful completion of modules of the cycle "Stochastic methods of econometrics" 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</p> <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Stochastic methods of econometrics" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>  Attendance time:  28 h  Self-study time:  62 h</p>
<b>Course: Seminar</b> (Seminar)	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Stochastic methods of econometrics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3343
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	

**Additional notes and regulations:**

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

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4844: Seminar on mathematical statistics</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Mathematical statistics" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Seminar (Seminar)</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b>	3 C

Participation in the seminar	
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Mathematical statistics"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3344
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4845: Seminar on statistical modelling and inference</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Statistical modelling and inference" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>		<p><b>Workload:</b> Attendance time: 28 h Self-study time: 62 h</p>
<b>Course: Seminar</b> (Seminar)		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>		3 C
<b>Examination prerequisites:</b> Participation in the seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Statistical modelling and inference"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3345	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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not specified	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4846: Seminar on multivariate statistics</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Multivariate statistics" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Seminar</b> (Seminar)</p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p>	<p>3 C</p>

<b>Examination prerequisites:</b> Participation in the seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Multivariate statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3346	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4847: Seminar on statistical foundations of data science</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• become acquainted with a mathematical topic in the area "Statistical foundations of data science" and present it in a talk;</li> <li>• conduct scholarly debates in a familiar context.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Seminar (Seminar)</b></p>	<p>2 WLH</p>

<b>Examination: Oral Presentation (approx. 75 minutes)</b>		3 C
<b>Examination prerequisites:</b> Participation in the seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues in the area "Statistical foundations of data science"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Mat.3347	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4911: Advanced seminar on analytic number theory</b>		
<p><b>Learning outcome, core skills:</b> <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• solve arithmetical problems with basic, complex-analytical, and Fourier-analytical methods;</li> <li>• know characteristics of the Riemann zeta function and more general L-functions, and apply them to problems of number theory;</li> <li>• are familiar with results and methods of prime number theory;</li> <li>• acquire knowledge in arithmetical and analytical theory of automorphic forms, and its application in number theory;</li> <li>• know basic sieving methods and apply them to the problems of number theory;</li> <li>• know techniques used to estimate the sum of the sum of characters and of exponentials;</li> <li>• analyse the distribution of rational points on suitable algebraic varieties using analytical techniques;</li> <li>• master computation with asymptotic formulas, asymptotic analysis, and asymptotic equipartition in number theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Analytic number theory" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>		<p><b>Workload:</b> Attendance time: 28 h Self-study time: 62 h</p>
<b>Course: Advanced seminar</b>		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>		3 C
<b>Examination prerequisites:</b> Participation in the advanced seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Analytic number theory"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4511	
<b>Language:</b>	<b>Person responsible for module:</b>	

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English	Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4912: Advanced seminar on analysis of partial differential equations</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the most important types of partial differential equations and know their solutions;</li> <li>• master the Fourier transform and other techniques of the harmonic analysis to analyse partial differential equations;</li> <li>• are familiar with the theory of generalised functions and the theory of function spaces and use these for solving differential partial equations;</li> <li>• apply the basic principles of functional analysis to the solution of partial different equations;</li> <li>• use different theorems of function theory for solving partial different equations;</li> <li>• master different asymptotic techniques to study characteristics of the solutions of partial different equations;</li> <li>• are paradigmatically familiar with broader application areas of linear theory of partial different equations;</li> <li>• are paradigmatically familiar with broader application areas of non-linear theory of partial different equations;</li> <li>• know the importance of partial different equations in the modelling in natural and engineering sciences;</li> <li>• master some advanced application areas like parts of microlocal analysis or parts of algebraic analysis.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Analysis of partial differential equations" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Participation in the advanced seminar</p>	<p>3 C</p>

<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Analysis of partial differential equations"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4512	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		



<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4913: Advanced seminar on differential geometry</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• master the basic concepts of differential geometry;</li> <li>• develop a spatial sense using the examples of curves, surfaces and hypersurfaces;</li> <li>• 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";</li> <li>• 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;</li> <li>• develop an understanding for geometrical constructs, spatial patterns and the interaction of algebraic, geometrical, analytical and topological methods;</li> <li>• acquire the skill to apply methods of analysis, algebra and topology for the treatment of geometrical problems;</li> <li>• are able to import geometrical problems to a broader mathematical and physical context.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Differential geometry" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b>                  Participation in the advanced seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b>                  Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Differential geometry"</p>	
<p><b>Admission requirements:</b></p>	<p><b>Recommended previous knowledge:</b></p>

none	M.Mat.4513
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4914: Advanced seminar on algebraic topology</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know the basic concepts of set-theoretic topology and continuous mappings;</li> <li>• construct new topologies from given topologies;</li> <li>• know special classes of topological spaces and their special characteristics like CW complexes, simplicial complexes and manifolds;</li> <li>• apply basic concepts of category theory to topological spaces;</li> <li>• use concepts of functors to obtain algebraic invariants of topological spaces and mappings;</li> <li>• know the fundamental group and the covering theory as well as the basic methods for the computation of fundamental groups and mappings between them;</li> <li>• 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;</li> <li>• calculate homology and cohomology with the aid of chain complexes;</li> <li>• deduce algebraic characteristics of homology and cohomology with the aid of homological algebra;</li> <li>• become acquainted with connections between analysis and topology;</li> <li>• apply algebraic structures to deduce special global characteristics of the cohomology of a local structure of manifolds.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Algebraic topology" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>	3 C

<b>Examination prerequisites:</b> Participation in the advanced seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic topology"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4514	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4915: Advanced seminar on mathematical methods in physics</b>		3 C 2 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> 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 <ul style="list-style-type: none"> <li>• harmonic analysis, algebraic structures and representation theory, (group) effects;</li> <li>• operator algebra, C* algebra and von-Neumann algebra;</li> <li>• operator theory, perturbation and scattering theory, special PDE, microlocal analysis, distributions;</li> <li>• (semi) Riemannian geometry, symplectic and Poisson geometry, quantization.</li> </ul> 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.  <b>Core skills:</b> After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Mathematical methods of physics" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Advanced seminar</b>		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar		3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Mathematical methods in physics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4515	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b>	<b>Duration:</b>	

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not specified	1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4921: Advanced seminar on algebraic geometry</b></p>	<p>3 C                  2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with commutative algebra, also in greater detail;</li> <li>• know the concepts of algebraic geometry, especially varieties, schemes, sheafs, bundles;</li> <li>• examine important examples like elliptic curves, Abelian varieties or algebraic groups;</li> <li>• use divisors for classification questions;</li> <li>• study algebraic curves;</li> <li>• prove the Riemann-Roch theorem and apply it;</li> <li>• use cohomological concepts and know the basics of Hodge theory;</li> <li>• apply methods of algebraic geometry to arithmetical questions and obtain e. g. finiteness principles for rational points;</li> <li>• classify singularities and know the significant aspects of the dimension theory of commutative algebra and algebraic geometry;</li> <li>• get to know connections to complex analysis and to complex geometry.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Algebraic geometry" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b>                  Participation in the advanced seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic geometry"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4521
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4922: Advanced seminar on algebraic number theory</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• know Noetherian and Dedekind rings and the class groups;</li> <li>• are familiar with discriminants, differentials and bifurcation theory of Hilbert;</li> <li>• 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);</li> <li>• are familiar with L-series and zeta functions and discuss the algebraic meaning of their residues;</li> <li>• know densities, the Tchebotarew theorem and applications;</li> <li>• work with orders, S-integers and S-units;</li> <li>• know the class field theory of Hilbert, Takagi and Idele theoretical field theory;</li> <li>• are familiar with <math>\mathbb{Z}_p</math>-extensions and their Iwasawa theory;</li> <li>• discuss the most important hypotheses of Iwasawa theory and their consequences.</li> </ul> <p>Concerning algorithmic aspects of number theory, the following competencies are pursued. Students</p> <ul style="list-style-type: none"> <li>• work with algorithms for the identification of short lattice bases, nearest points in lattices and the shortest vectors;</li> <li>• 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;</li> <li>• use the sieving method for factorisation and calculation of discrete logarithms in finite fields of great characteristics;</li> <li>• discuss algorithms for the calculation of the zeta function of elliptic curves and Abelian varieties of finite fields;</li> <li>• calculate class groups and fundamental units;</li> <li>• calculate Galois groups of absolute number fields.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Algebraic number theory" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>

<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic number theory"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4522
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4923: Advanced seminar on algebraic structures</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• know basic concepts like rings, modules, algebras and Lie algebras;</li> <li>• know important examples of Lie algebras and algebras;</li> <li>• know special classes of Lie groups and their special characteristics;</li> <li>• know classification theorems for finite-dimensional algebras;</li> <li>• apply basic concepts of category theory to algebras and modules;</li> <li>• know group actions and their basic classifications;</li> <li>• apply the enveloping algebra of Lie algebras;</li> <li>• apply ring and module theory to basic constructs of algebraic geometry;</li> <li>• use combinatorial tools for the study of associative algebras and Lie algebras;</li> <li>• 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;</li> <li>• know Hopf algebras as well as their deformation and representation theory.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Algebraic structures" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>
<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b>	

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Algebraic structures"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4523	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4924: Advanced seminar on groups, geometry and dynamical systems</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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.</p> <p>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.</p> <p>Students</p> <ul style="list-style-type: none"> <li>• know basic concepts of groups and group homomorphisms;</li> <li>• know important examples of groups;</li> <li>• know special classes of groups and their special characteristics;</li> <li>• apply basic concepts of category theory to groups and define spaces via universal properties;</li> <li>• apply the concepts of functors to obtain algebraic invariants;</li> <li>• know group actions and their basic classification results;</li> <li>• know the basics of group cohomology and compute these for important examples;</li> <li>• know the basics of geometrical group theory like growth characteristics;</li> <li>• know self-similar groups, their basic constructs as well as examples with interesting characteristics;</li> <li>• use geometrical and combinatorial tools for the study of groups;</li> <li>• know the basics of the representation theory of compact Lie groups.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Groups, geometry and dynamical systems" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Participation in the advanced seminar</p>	<p>3 C</p>
<p><b>Examination requirements:</b></p>	

Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Groups, geometry and dynamical systems"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4524
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4925: Advanced seminar on non-commutative geometry</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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.</p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the basic characteristics of operator algebras, especially with their representation and ideal theory;</li> <li>• construct groupoids and operator algebras from different geometrical objects and apply non-commutative geometry to these domains;</li> <li>• know the spectral theory of commutative <math>C^*</math>-algebras and analyse normal operators in Hilbert spaces with it;</li> <li>• know important examples of simple <math>C^*</math>-algebras and deduce their basic characteristics;</li> <li>• apply basic concepts of category theory to <math>C^*</math>-algebras;</li> <li>• model the symmetries of non-commutative spaces;</li> <li>• apply Hilbert modules in <math>C^*</math>-algebras;</li> <li>• know the definition of the K-theory of <math>C^*</math>-algebras and their formal characteristics and calculate the K-theory of <math>C^*</math>-algebras for important examples with it;</li> <li>• apply operator algebras for the formulation and analysis of index problems in geometry and for the analysis of the geometry of greater length scales;</li> <li>• compare different analytical and geometrical models for the construction of mappings between K-theory groups and apply them;</li> <li>• classify and analyse quantisations of manifolds via Poisson structures and know a few important methods for the construction of quantisations;</li> <li>• classify <math>W^*</math>-algebras and know the intrinsic dynamic of factors;</li> <li>• apply von Neumann algebras to the axiomatic formulation of quantum field theory;</li> <li>• use von Neumann algebras for the construction of L2 invariants for manifolds and groups;</li> <li>• understand the connection between the analysis of <math>C^*</math>- and <math>W^*</math>-algebras of groups and geometrical characteristics of groups;</li> <li>• define the invariants of algebras and modules with chain complexes and their homology and calculate these;</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h</p> <p>Self-study time:  62 h</p>

<ul style="list-style-type: none"> <li>• interpret these homological invariants geometrically and correlate them with each other;</li> <li>• abstract new concepts from the fundamental characteristics of K-theory and other homology theories, e. g. triangulated categories.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Non-commutative geometry" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	
<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Non-commutative geometry"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4525
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Mathematical Institute	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4931: Advanced seminar on inverse problems</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the phenomenon of illposedness and identify the degree of illposedness of typical inverse problems;</li> <li>• 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;</li> <li>• analyse the convergence of regularisation methods with the help of spectral theory of bounded self-adjoint operators;</li> <li>• analyse the convergence of regularisation methods with the help of complex analysis;</li> <li>• analyse regularisation methods from stochastic error models;</li> <li>• apply fully data-driven models for the choice of regularisation parameters and evaluate these for concrete problems;</li> <li>• 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;</li> <li>• analyse the uniqueness and conditional stability of inverse problems of partial differential equations;</li> <li>• deduce sampling and testing methods for the solution of inverse problems of partial differential equations and analyse the convergence of such methods;</li> <li>• formulate mathematical models of medical imaging like computer tomography (CT) or magnetic resonance tomography (MRT) and know the basic characteristics of corresponding operators.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Inverse problems" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Participation in the advanced seminar</p>	<p>3 C</p>

<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Inverse problems"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4531	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b>  <b>Module M.Mat.4932: Advanced seminar on approximation methods</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of approximation problems in suitable finite- and infinite-dimensional vector spaces;</li> <li>• can confidently handle models for the approximation of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• 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;</li> <li>• acquire knowledge of continuous and discrete approximation problems and their corresponding solution strategies both in the one- and multidimensional case;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear approximation methods for multidimensional data;</li> <li>• are informed about current developments of efficient data approximation and data analysis;</li> <li>• adapt solution strategies for the data approximation using special structural characteristics of the approximation problem that should be solved.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Approximation methods" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b>  Attendance time: 28 h  Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b>  <b>Examination prerequisites:</b></p>	<p>3 C</p>

Participation in the advanced seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Approximation methods"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4532	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4933: Advanced seminar on numerical methods of partial differential equations</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• know the basics of the theory of linear integral equations;</li> <li>• 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);</li> <li>• analyse stability, consistence and convergence of FDM, FEM and BEM for linear problems;</li> <li>• apply methods for adaptive lattice refinement on the basis of a posteriori error approximations;</li> <li>• know methods for the solution of larger systems of linear equations and their preconditioners and parallelisation;</li> <li>• 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;</li> <li>• apply available software for the solution of partial differential equations and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• 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;</li> <li>• know propositions about the theory of non-linear partial differential equations of monotone and maximally monotone type as well as suitable iterative solution methods.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Numerics of partial differential equations" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>

<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Numerical methods of partial differential equations"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4533
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4934: Advanced seminar on optimisation</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• identify optimisation problems in application-oriented problems and formulate these as mathematical programmes;</li> <li>• evaluate the existence and uniqueness of the solution of an optimisation problem;</li> <li>• identify structural characteristics of an optimisation problem, amongst others the existence of a finite candidate set, the structure of the underlying level set;</li> <li>• 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;</li> <li>• analyse the complexity of an optimisation problem;</li> <li>• classify a mathematical programme in a class of optimisation problems and know current solution strategies for it;</li> <li>• develop optimisation methods and adapt general methods to special problems;</li> <li>• deduce upper and lower bounds for optimisation problems and understand their meaning;</li> <li>• understand the geometrical structure of an optimisation problem and apply it for solution strategies;</li> <li>• 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;</li> <li>• 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;</li> <li>• acquire advanced knowledge for the solution of special optimisation problems of an application-oriented area, e. g. traffic planning or location planning;</li> <li>• handle advanced optimisation problems, like e. g. optimisation problems with uncertainty or multi-criteria optimisation problems.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Optimisation" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Optimisation"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4534
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4937: Advanced seminar on variational analysis</b></p>	<p>3 C 2 WLH</p>
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<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• understand basic concepts of convex and variational analysis for finite- and infinite-dimensional problems;</li> <li>• 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;</li> <li>• understand basic concepts of the convergence of sets and continuity of set-valued functions;</li> <li>• understand basic concepts of variational geometry;</li> <li>• calculate and use generalised derivations (subderivatives and subgradients) of non-smooth functions;</li> <li>• understand the different concepts of regularity of set-valued functions and their effects on the calculation rules for subderivatives of non-convex functionals;</li> <li>• analyse constrained and parametric optimisation problems with the help of duality theory;</li> <li>• calculate and use the Legendre-Fenchel transformation and infimal convolutions;</li> <li>• formulate optimality criteria for continuous optimisation problems with tools of convex and variational analysis;</li> <li>• apply tools of convex and variational analysis to solve generalised inclusions that e. g. originate from first-order optimality criteria;</li> <li>• understand the connection between convex functions and monotone operators;</li> <li>• examine the convergence of fixed point iterations with the help of the theory of monotone operators;</li> <li>• deduce methods for the solution of smooth and non-smooth continuous constrained optimisation problems and analyse their convergence;</li> <li>• apply numerical methods for the solution of smooth and non-smooth continuous constrained programs to current problems;</li> <li>• model application problems with variational inequations, analyse their characteristics and are familiar with numerical methods for the solution of variational inequations;</li> <li>• know applications of control theory and apply methods of dynamic programming;</li> <li>• use tools of variational analysis in image processing and with inverse problems;</li> <li>• know basic concepts and methods of stochastic optimisation.</li> </ul> <p><b>Core skills:</b></p>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
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After having successfully completed the module, students will be able to	
<ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Variational analysis" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	
<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Variational analysis"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4537
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> Instructor: Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4938: Advanced seminar on image and geometry processing</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the modelling of problems of image and geometry processing in suitable finite- and infinite-dimensional vector spaces;</li> <li>• learn basic methods for the analysis of one- and multidimensional functions in Banach and Hilbert spaces;</li> <li>• learn basic mathematical concepts and methods that are used in image processing, like Fourier and Wavelet transform;</li> <li>• learn basic mathematical concepts and methods that play a central role in geometry processing, like curvature of curves and surfaces;</li> <li>• acquire knowledge about continuous and discrete problems of image data analysis and their corresponding solution strategies;</li> <li>• know basic concepts and methods of topology;</li> <li>• are familiar with visualisation software;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• know which special characteristics of an image or of a geometry can be extracted and worked on with which methods;</li> <li>• 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;</li> <li>• acquire advanced knowledge about linear and non-linear methods for the geometrical and topological analysis of multidimensional data;</li> <li>• are informed about current developments of efficient geometrical and topological data analysis;</li> <li>• adapt solution strategies for the data analysis using special structural characteristics of the given multidimensional data.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Image and geometry processing" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Image and geometry processing"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4538
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4939: Advanced seminar on scientific computing / applied mathematics</b>	3 C 2 WLH
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<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with the theory of basic mathematical models of the corresponding subject area, especially about the existence and uniqueness of solutions;</li> <li>• know basic methods for the numerical solution of these models;</li> <li>• analyse stability, convergence and efficiency of numerical solution strategies;</li> <li>• apply available software for the solution of the corresponding numerical methods and evaluate the results sceptically;</li> <li>• evaluate different numerical methods on the basis of the quality of the solutions, the complexity and their computing time;</li> <li>• are informed about current developments of scientific computing, like e. g. GPU computing and use available soft- and hardware;</li> <li>• use methods of scientific computing for solving application problems, like e. g. of natural and business sciences.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Scientific computing / applied mathematics" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b>                  Attendance time:                  28 h                  Self-study time:                  62 h</p>
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<b>Course: Advanced seminar</b>	2 WLH
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<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
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<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Scientific computing / applied mathematics"	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4539
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<b>Language:</b>	<b>Person responsible for module:</b>
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English	Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics	

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4941: Advanced seminar on applied and mathematical stochastics</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• are familiar with substantial concepts and approaches of probability modelling and inferential statistics;</li> <li>• know basic characteristics of stochastic processes as well as conditions for their existence and uniqueness;</li> <li>• have a pool of different stochastic processes in time and space at their disposal and characterise those, differentiate them and quote examples;</li> <li>• understand and identify basic characteristics of invariance of stochastic processes like stationary processes and isotropy;</li> <li>• analyse the convergence characteristic of stochastic processes;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• adequately model temporal and spatial phenomena in natural and economic sciences as stochastic processes, if necessary with unknown parameters;</li> <li>• 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;</li> <li>• discuss and compare different modelling approaches and evaluate the reliability of parameter estimates and predictions sceptically.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Applied and mathematical stochastics" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p> <p><b>Examination prerequisites:</b></p> <p>Participation in the advanced seminar</p>	<p>3 C</p>

<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Applied and mathematical stochastics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4541	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Numerical and Applied Mathematics		



<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4942: Advanced seminar on stochastic processes</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• are familiar with advanced concepts of probability theory established on measure theory and apply them independently;</li> <li>• know basic characteristics as well as existence and uniqueness results for stochastic processes and formulate suitable probability spaces;</li> <li>• understand the relevance of the concepts of filtration, conditional expectation and stopping time for the theory of stochastic processes;</li> <li>• 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;</li> <li>• analyse regularity characteristics of the paths of stochastic processes;</li> <li>• construct Markov chains with discrete and general state spaces in discrete and continuous time, classify their states and analyse their characteristics;</li> <li>• 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;</li> <li>• 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;</li> <li>• formulate stochastic integrals as well as stochastic differential equations with the use of the Ito calculus and analyse their characteristics;</li> <li>• are familiar with stochastic concepts in general state spaces as well as with the topologies, metrics and convergence theorems relevant for stochastic processes;</li> <li>• know fundamental convergence theorems for stochastic processes and generalise these;</li> <li>• model stochastic systems from different application areas in natural sciences and technology with the aid of suitable stochastic processes;</li> <li>• analyse models in mathematical economics and finance and understand evaluation methods for financial products.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>

<ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Stochastic processes" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	
<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar	3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Stochastic processes"	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4542
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4943: Advanced seminar on stochastic methods in econometrics</b>		3 C 2 WLH
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> The successful completion of modules of the cycle "Stochastic methods of econometrics" 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 <ul style="list-style-type: none"> <li>• master problems, basic concepts and stochastic methods of econometrics;</li> <li>• understand stochastic connections;</li> <li>• understand references to other mathematical areas;</li> <li>• get to know possible applications in theory and practice;</li> <li>• gain insight into the connection of mathematics and economic sciences.</li> </ul> <b>Core skills:</b> After having successfully completed the module, students will be able to <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Stochastic methods in econometrics" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Advanced seminar</b>		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar		3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Stochastic methods in econometrics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4543	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		

**Additional notes and regulations:**

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

<b>Georg-August-Universität Göttingen</b> <b>Module M.Mat.4944: Advanced seminar on mathematical statistics</b>	3 C 2 WLH
<p><b>Learning outcome, core skills:</b>  <b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable risk and loss concepts;</li> <li>• analyse optimality characteristics of statistical estimate methods via lower and upper bounds;</li> <li>• analyse the error rates of statistical testing and classification methods based on the Neyman Pearson theory;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential indexed families;</li> <li>• know different techniques to obtain lower and upper risk bounds in these models;</li> <li>• are confident in modelling typical data structures of regression;</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of mathematical statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Mathematical statistics" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time:  28 h  Self-study time:  62 h</p>
<b>Course: Advanced seminar</b>	2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b>	3 C

<b>Examination prerequisites:</b> Participation in the advanced seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Mathematical statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4544	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<b>Georg-August-Universität Göttingen</b>		3 C 2 WLH
<b>Module M.Mat.4945: Advanced seminar on statistical modelling and inference</b>		
<b>Learning outcome, core skills:</b> <b>Learning outcome:</b> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• are familiar with the tools of asymptotic statistical inference;</li> <li>• learn Bayes and frequentist approaches to data modelling and inference, as well as the interplay between both, in particular empirical Bayes methods;</li> <li>• are able to implement Monte Carlo statistical methods for Bayes and frequentist inference and learn their theoretical properties;</li> <li>• become confident in non-parametric (regression) modelling and inference for various types of the data: count, categorical, dependent, etc.;</li> <li>• are able to develop and mathematically evaluate complex statistical models for real data problems.</li> </ul> <b>Core skills:</b> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Statistical modelling and inference" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 62 h
<b>Course: Advanced seminar</b>		2 WLH
<b>Examination: Oral Presentation (approx. 75 minutes)</b> <b>Examination prerequisites:</b> Participation in the advanced seminar		3 C
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Statistical modelling and inference"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4545	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	

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<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics	



<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4946: Advanced seminar on multivariate statistics</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• can apply more specific methods of multivariate statistics such as dimension reduction by principal component analysis (PCA), factor analysis and multidimensional scaling;</li> <li>• are familiar with handling non-Euclidean data such as directional or shape data using parametric and non-parametric models;</li> <li>• are confident using nested descriptors for non-Euclidean data and Procrustes methods in shape analysis;</li> <li>• are familiar with time dependent data, basic functional data analysis and inferential concepts such as kinematic formulae;</li> <li>• analyze basic dependencies between topology/geometry of underlying spaces and asymptotic limiting distributions;</li> <li>• are confident to apply resampling methods to non-Euclidean descriptors;</li> <li>• are familiar with high-dimensional discrimination and classification techniques such as kernel PCA, regularization methods and support vector machines;</li> <li>• have a fundamental knowledge of statistics of point processes and Bayesian methods involved;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• independently become acquainted with a current topic of multivariate and non-Euclidean statistics;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Multivariate statistics" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h</p> <p>Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>
<p><b>Examination: Oral Presentation (approx. 75 minutes)</b></p>	<p>3 C</p>

<b>Examination prerequisites:</b> Participation in the advanced seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Multivariate statistics"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4546	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Module M.Mat.4947: Advanced seminar on statistical foundations of data science</b></p>	<p>3 C 2 WLH</p>
<p><b>Learning outcome, core skills:</b></p> <p><b>Learning outcome:</b></p> <p>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</p> <ul style="list-style-type: none"> <li>• 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;</li> <li>• evaluate statistical methods mathematically precisely via suitable statistical risk and loss concepts;</li> <li>• analyse characteristics of statistical estimation methods via lower and upper information bounds;</li> <li>• are familiar with basic statistical distribution models that base on the theory of exponential families;</li> <li>• are confident in modelling real world data structures such as categorical data, multidimensional and high dimensional data, data in imaging, data with serial dependencies</li> <li>• 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;</li> <li>• are able to mathematically analyse resampling methods and apply them purposively;</li> <li>• are familiar with concepts of large scale computational statistical techniques;</li> <li>• are familiar with advanced tools of non-parametric statistics and empirical process theory;</li> <li>• independently become acquainted with a current topic of statistical data science;</li> <li>• evaluate complex statistical methods and enhance them in a problem-oriented way.</li> </ul> <p><b>Core skills:</b></p> <p>After having successfully completed the module, students will be able to</p> <ul style="list-style-type: none"> <li>• present a mathematical topic of current research interest in the area "Statistical foundations of data science" in a talk;</li> <li>• conduct scholarly debates with reference to current research.</li> </ul>	<p><b>Workload:</b></p> <p>Attendance time: 28 h Self-study time: 62 h</p>
<p><b>Course: Advanced seminar</b></p>	<p>2 WLH</p>

<b>Examination: Oral Presentation (approx. 75 minutes)</b>		3 C
<b>Examination prerequisites:</b> Participation in the advanced seminar		
<b>Examination requirements:</b> Autonomous permeation and presentation of complex mathematical issues of current research literature in the area "Statistical foundations of data science"		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.Mat.4547	
<b>Language:</b> English	<b>Person responsible for module:</b> Dean of studies	
<b>Course frequency:</b> not specified	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 4	
<b>Maximum number of students:</b> not limited		
<b>Additional notes and regulations:</b> <b>Instructor:</b> Lecturers at the Institute of Mathematical Stochastics		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul M.Phi.101: Ausgewählte Themen der Theoretischen Philosophie</b></p> <p><i>English title: Selected Topics in Theoretical Philosophy</i></p>	<p>9 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>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.</p> <p>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.</p>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden</p>
<p><b>Lehrveranstaltung: Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der theoretischen Philosophie</b></p>	<p>2 SWS</p>
<p>Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:</p>	
<p><b>Prüfung: Hausarbeit (max. 15 Seiten)</b></p> <p><b>Prüfungsvorleistungen:</b> Eine kleine Leistung mindestens in Textform (max. 3 Seiten)</p> <p><b>Prüfungsanforderungen:</b> 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.</p>	<p>7 C</p>
<p><b>Prüfung: Mündlich (ca. 30 Minuten)</b></p> <p><b>Prüfungsvorleistungen:</b> Eine kleine Leistung mindestens in Textform (max. 3 Seiten)</p> <p><b>Prüfungsanforderungen:</b> 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.</p>	<p>7 C</p>
<p><b>Lehrveranstaltung: Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der theoretischen Philosophie</b></p>	<p>2 SWS</p>
<p><b>Prüfung: Eine kleine Leistung mindestens in Textform (max. 3 Seiten), unbenotet</b></p> <p><b>Prüfungsanforderungen:</b></p>	<p>2 C</p>

Fähigkeit, sich mit wichtigen Positionen der Sprachphilosophie, Erkenntnistheorie, Philosophie des Geistes, Wissenschaftsphilosophie oder Metaphysik auseinanderzusetzen und in kurzer schriftlicher Form einzelne Fragen, Probleme oder Lösungsvorschläge argumentativ verständlich darzulegen. Bei der kleinen Leistung kann es sich um ein Protokoll, ein Handout zu einem Referat, die Bearbeitung von Aufgaben oder Fragen zur Textvor- oder Nachbereitung, einen kurzen Essay oder Vergleichbares (je nach Arbeitsform der betreffenden Veranstaltung) handeln.	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Catrin Misselhorn
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1-2 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 3
<b>Maximale Studierendenzahl:</b> 25	

<b>Bemerkungen:</b> Von den zwei Lehrveranstaltungen darf nur eine in Form einer Vorlesung besucht werden, die andere muss ein Seminar oder Hauptseminar sein.
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<b>Georg-August-Universität Göttingen</b> <b>Modul M.Phi.102: Ausgewählte Themen der Praktischen Philosophie</b> <i>English title: Selected Topics in Practical Philosophy</i>		9 C 4 SWS
<b>Lernziele/Kompetenzen:</b> 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.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden
<b>Lehrveranstaltung: Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der praktischen Philosophie</b>		2 SWS
Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:		
<b>Prüfung: Hausarbeit (max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> Eine kleine Leistung mindestens in Textform (max. 3 Seiten)		7 C
<b>Prüfung: Mündlich (ca. 30 Minuten)</b> <b>Prüfungsvorleistungen:</b> Eine kleine Leistung mindestens in Textform (max. 3 Seiten)		7 C
<b>Lehrveranstaltung: Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der praktischen Philosophie</b>		2 SWS
<b>Prüfung: Eine kleine Leistung mindestens in Textform (max. 3 Seiten), unbenotet</b> <b>Prüfungsanforderungen:</b> Fähigkeit, sich mit wichtigen Positionen der Theoretischen Ethik, der Angewandten Ethik oder der Politischen Philosophie auseinanderzusetzen und in kurzer schriftlicher Form einzelne Fragen, Probleme oder Lösungsvorschläge argumentativ verständlich darzulegen. Bei der kleinen Leistung kann es sich um ein Protokoll, ein Handout zu einem Referat, die Bearbeitung von Aufgaben oder Fragen zur Textvor- oder Nachbereitung, einen kurzen Essay oder Vergleichbares (je nach Arbeitsform der betreffenden Veranstaltung) handeln.		2 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine	
<b>Sprache:</b>	<b>Modulverantwortliche[r]:</b>	

Deutsch	Prof. Dr. Holmer Steinfath
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1-2 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 3
<b>Maximale Studierendenzahl:</b> 25	
<b>Bemerkungen:</b> Von den zwei Lehrveranstaltungen darf nur eine in Form einer Vorlesung besucht werden, die andere muss ein Seminar oder Hauptseminar sein.	



<b>Georg-August-Universität Göttingen</b> <b>Modul M.Phi.103: Ausgewählte Themen der Geschichte der Philosophie</b> <i>English title: Selected Topics in History of Philosophy</i>	9 C 4 SWS
<b>Lernziele/Kompetenzen:</b> 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.	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 214 Stunden
<b>Lehrveranstaltung: Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der Geschichte der Philosophie</b>	2 SWS
Von den folgenden Prüfungen ist genau eine erfolgreich zu absolvieren:	
<b>Prüfung: Hausarbeit (max. 15 Seiten)</b> <b>Prüfungsvorleistungen:</b> Eine kleine Leistung mindestens in Textform (max. 3 Seiten) <b>Prüfungsanforderungen:</b> 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.	7 C
<b>Prüfung: Mündlich (ca. 30 Minuten)</b> <b>Prüfungsvorleistungen:</b> Eine kleine Leistung mindestens in Textform (max. 3 Seiten) <b>Prüfungsanforderungen:</b> 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.	7 C
<b>Lehrveranstaltung: Vorlesung für Fortgeschrittene (= nicht Einführungskurs), Seminar oder Hauptseminar zu einem Thema der Geschichte der Philosophie</b>	2 SWS
<b>Prüfung: Eine kleine Leistung mindestens in Textform (max. 3 Seiten), unbenotet</b> <b>Prüfungsanforderungen:</b> Fähigkeit, sich mit wichtigen philosophiegeschichtlichen Werken und Positionen auseinanderzusetzen, sie sachgemäß zu interpretieren sowie in ihren historischen und systematischen Kontexten einzuordnen. Fähigkeit, in kurzer schriftlicher Form einzelne	2 C

Fragen, Probleme oder Lösungsvorschläge argumentativ verständlich darzulegen. Bei der kleinen Leistung kann es sich um ein Protokoll, ein Handout zu einem Referat, die Bearbeitung von Aufgaben oder Fragen zur Textvor- oder Nachbereitung, einen kurzen Essay oder Vergleichbares (je nach Arbeitsform der betreffenden Veranstaltung) handeln.	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> keine
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Bernd Ludwig
<b>Angebotshäufigkeit:</b> jedes Semester	<b>Dauer:</b> 1-2 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 3
<b>Maximale Studierendenzahl:</b> 25	

<b>Bemerkungen:</b> Von den zwei Lehrveranstaltungen darf nur eine in Form einer Vorlesung besucht werden, die andere muss ein Seminar oder Hauptseminar sein.
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<b>Georg-August-Universität Göttingen</b>		4 C 2 WLH
<b>Module M.Phy.5601: Seminar Computational Neuroscience/Neuroinformatics</b>		
<b>Learning outcome, core skills:</b> After successful completion of the module, students ... <ul style="list-style-type: none"> <li>• have deepened their knowledge of computational neuroscience / neuroinformatics by an independent elaboration of a topic;</li> <li>• have learned methods of presentation of topics from computer science;</li> <li>• are able to deal with (English-language) literature;</li> <li>• are able to present an informatic topic;</li> <li>• are able to lead a scientific discussion.</li> </ul>		<b>Workload:</b> Attendance time: 28 h Self-study time: 92 h
<b>Course: Seminar</b> (Seminar) <i>Course frequency:</i> each semester		
<b>Examination: Presentation (approx. 45 Min.) with written report (max. 7 S.)</b> <b>Examination prerequisites:</b> regular participation <b>Examination requirements:</b> Independent preparation and presentation of research-related topics from the area of computational neuroscience / neuroinformatics as well as biophysics of neuronal systems.		4 C
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.Phy.5614	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Florentin Andreas Wörgötter	
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> Master: 1 - 3	
<b>Maximum number of students:</b> 14		

<b>Georg-August-Universität Göttingen</b> <b>Modul M.WIWI-BWL.0001: Finanzwirtschaft</b> <i>English title: Corporate Finance</i>	6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Mit dem erfolgreichen Abschluss des Moduls haben die Studierenden folgende Kompetenzen erworben: <ul style="list-style-type: none"> <li>• sie sind in der Lage einen vertieften Überblick über die grundlegenden Fragen der betrieblichen Finanzwirtschaft und ihre Verbindungen zueinander zu geben,</li> <li>• sie können die zentralen Methoden der Risikoanalyse und der Beurteilung von Investitionen verstehen, anwenden und kritisch reflektieren,</li> <li>• sie verstehen die zentrale Theorien zur Marktbewertung riskanter Zahlungsströme und können diese kritisch reflektieren,</li> <li>• sie verstehen die Hypothesen zur Informationseffizienz von Kapitalmärkten können und deren Konsequenzen für Investoren und Unternehmen beurteilen,</li> <li>• sie verstehen verhaltenswissenschaftliche Aspekte in Finanzmärkten, deren ökonomische Fundierung und deren Auswirkungen auf Investitions- und Finanzierungsentscheidungen und sind in der Lage diese kritisch zu reflektieren,</li> <li>• sie verstehen Theorien zur optimalen Kapitalstruktur und Dividendenpolitik von Unternehmen und können deren Verbindungen zu verschiedenen Marktfraktionen und Prinzipal-Agenten-Problemen aufzeigen,</li> <li>• sie sind in der Lage Theorien zur optimalen Kapitalstruktur und Dividendenpolitik von Unternehmen hinsichtlich ihrer praktischen Implikationen und ihrer Fähigkeit zur Erklärung empirischer Phänomene zu beurteilen.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Finanzwirtschaft (Vorlesung)</b> <i>Inhalte:</i> <ol style="list-style-type: none"> <li>1. Grundlegende Fragestellungen der betrieblichen Finanzwirtschaft</li> <li>2. Investitionsentscheidungen unter Risiko: Risikoanalyse und subjektive Bewertung</li> <li>3. Investitionsentscheidungen unter Risiko: Marktbewertung - Bewertungsmodelle (Capital Asset Pricing Model, Arbitrage Pricing Theory, Empirische Faktormodelle)</li> <li>4. Investitionsentscheidungen unter Risiko: Marktbewertung - Implementierung</li> <li>5. Finanzierungsinstrumente, effiziente Kapitalmärkte, Behavioral Finance und Finanzierungsentscheidungen</li> <li>6. Kapitalstrukturentscheidungen</li> <li>7. Dividenden und Ausschüttungspolitik</li> </ol> Teile des Materials der Vorlesungen werden durch Aufzeichnungen vermittelt, die von den Studierenden eigenständig durchzuarbeiten sind.	2 SWS
<b>Lehrveranstaltung: Finanzwirtschaft (Übung)</b> <i>Inhalte:</i> Im Rahmen der begleitenden Übung vertiefen und erweitern die Studierenden die in der Vorlesung erworbenen Kenntnisse und Fähigkeiten	2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>	6 C
<b>Prüfungsanforderungen:</b>	

<ul style="list-style-type: none"> <li>• Darlegung eines übergreifenden Verständnisses grundlegender finanzwirtschaftlicher Fragestellungen,</li> <li>• Nachweis der Kenntnis zentraler Methoden der Risikoanalyse und der Beurteilung von Investitionen unter Risiko sowie der Fähigkeit diese anzuwenden,</li> <li>• Nachweis des Verständnisses zentraler Theorien zur Marktbewertung riskanter Zahlungsströme und der Fähigkeit zur kritischen Beurteilung dieser Theorien,</li> <li>• Nachweis des Verständnisses der Hypothesen zur Informations-effizienz von Kapitalmärkten, verhaltenswissenschaftlicher Phänomene auf Kapitalmärkten sowie deren praktischer Implikationen für Investoren und Unternehmen,</li> <li>• Fähigkeit zur Analyse von Fragen der optimalen Kapitalstruktur und der Dividendenpolitik von Unternehmen vor dem Hintergrund verschiedener Marktfraktionen und Prinzipal-Agenten-Problemen.</li> </ul>	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Grundkenntnisse aus finanzwirtschaftlichen Veranstaltungen im Bachelorstudium
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Olaf Korn
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 2
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul M.WIWI-BWL.0002: Rechnungslegung nach IFRS</b> <i>English title: IFRS Financial Reporting</i>		6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Gegenstand der Veranstaltung sind die Ziele, Instrumente, Prinzipien und Einzelregelungen der Rechnungslegung nach den International Financial Reporting Standards (IFRS). Mit erfolgreicher Teilnahme am Moduls sind die Studierenden in der Lage die kennengelernten Regelungen einzuordnen, kritisch zu hinterfragen und anzuwenden. Darüber hinaus können die Teilnehmer unterschiedliche Sachverhalte in Bilanzierungs- und Offenlegungsregelungen einordnen, diese kritisch würdigen und prinzipienorientierte Lösungen entwickeln.		<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Rechnungslegung nach IFRS (Vorlesung)</b> <i>Inhalte:</i> I. Die „IFRS-Revolution“ II. Das Konzept der kapitalmarktorientierten Rechnungslegung III. Institutionelle Grundlagen IV. Rechnungslegungsprinzipien in den IFRS V. Bestandteile des Jahresabschlusses nach IFRS VI. Ansatz und Bewertung nach den IFRS		2 SWS
<b>Lehrveranstaltung: Rechnungslegung nach IFRS (Übung)</b> <i>Inhalte:</i> Im Rahmen der begleitenden Übung vertiefen und erweitern die Studierenden die in der Vorlesung erworbenen Kenntnisse und Fähigkeiten.		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Darlegung eines übergreifenden Verständnisses grundlegender Fragestellungen der internationalen Rechnungslegung und des damit verbundenen institutionellen Rahmens,</li> <li>• Nachweis der Kenntnis zentraler Regelungen der Rechnungslegung nach IFRS und der Fähigkeit diese anzuwenden.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Grundkenntnisse der Buchführung sowie der Bilanzierung nach Handelsrecht und IFRS werden vorausgesetzt	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Jörg-Markus Hitz	
<b>Angebotshäufigkeit:</b> jedes Wintersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b>	<b>Empfohlenes Fachsemester:</b>	

zweimalig	1 - 2
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Modul M.WIWI-BWL.0003: Unternehmensbesteuerung</b> <i>English title: Company Taxation</i>	6 C 4 SWS
<b>Lernziele/Kompetenzen:</b> Mit Abschluss haben die Studierenden folgende Kompetenzen erworben: <ul style="list-style-type: none"> <li>• Quantifizierung von rechtlichen Steuerbelastungen (steuerzahlungen) mittels geeigneter Verfahren sowie die Fähigkeit, Vor- und Nachteile dieser Verfahren diskutieren zu können,</li> <li>• Berechnung und Interpretation verschiedener Ausprägungen der wirtschaftlichen Steuerbelastung sowie ihrer Würdigung bezüglich ihrer Abhängigkeiten von steuerlichen Parametern,</li> <li>• Kenntnis über die Preiswirkungen der Besteuerung sowie die Fähigkeit, sie in konkreten Sachverhalten herausarbeiten zu können,</li> <li>• Kenntnis über ökonomisch bedeutsame Neutralitäten, die durch die Besteuerung nicht verletzt werden sollten,</li> <li>• Fähigkeit, Verfahren aufzuzeigen und anzuwenden, die eine entscheidungsneutrale Besteuerung gewährleisten,</li> <li>• Beurteilung von konkreten steuerlichen Gewinnermittlungsvorschriften hinsichtlich ihrer Entscheidungswirkungen anhand geeigneter Methoden und</li> <li>• Durchführung von Steuerwirkungsanalysen und steuerlichen Vorteilhaftigkeitsvergleichen.</li> </ul>	<b>Arbeitsaufwand:</b> Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden
<b>Lehrveranstaltung: Unternehmensbesteuerung (Vorlesung)</b> <i>Inhalte:</i> Die Vorlesung soll den Studierenden die wirtschaftlichen Wirkungen der Besteuerung (Steuerlastlehre und Neutralitätsüberlegungen) sowie die grundlegenden Einflussfaktoren bei Steuerplanungsüberlegungen vermitteln. Hierzu gliedert sich die Vorlesung in vier Kapitel. Im ersten Kapitel erfolgt eine Einordnung der Besteuerung in die betriebswirtschaftliche Entscheidungstheorie. Im zweiten Kapitel werden Verfahren zur Messung von Steuerzahlungen und Steuerbelastungen behandelt und Formen steuerlicher Neutralität unterschieden, die aus ökonomischer Sicht durch die Besteuerung nicht verletzt werden sollten. Im dritten Kapitel werden den Studierenden institutionelle Grundlagen der Unternehmensbesteuerung vermittelt. Das vierte Kapitel bietet eine Einführung in Steuerwirkungsanalysen in Bezug auf rein nationale Sachverhalte.	2 SWS
<b>Lehrveranstaltung: Unternehmensbesteuerung (Übung)</b> <i>Inhalte:</i> Im Rahmen der begleitenden Übung vertiefen, ergänzen und erweitern die Studierenden die in der Vorlesung erworbenen Kenntnisse und Fähigkeiten. Insbesondere werden mit den Studierenden Übungsfälle erarbeitet und diskutiert, mithilfe derer ein tieferes Verständnis für die praktische Anwendung der in der Vorlesung theoretisch vermittelten Inhalte geschaffen wird.	2 SWS



<b>Prüfung: Klausur (90 Minuten)</b>	6 C
<b>Prüfungsanforderungen:</b> Die Studierenden erbringen den Nachweis von Kenntnissen der wirtschaftlichen Wirkungen der Besteuerung sowie grundlegender Steuerplanungsüberlegungen und zeigen, dass sie in der Lage sind, diese auf spezifische Sachverhalte anwenden können. Ferner erbringen die Studierenden den Nachweis über den Erwerb grundlegender Kenntnisse der Besteuerung alternativer Rechtsformen.	
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> B.WIWI-BWL.0001 Unternehmenssteuern I
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Andreas Oestreicher
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 2
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Module M.WIWI-BWL.0004: Financial Risk Management</b>	6 C 4 WLH
<b>Learning outcome, core skills:</b> After a successful completion of the course students are able to: <ul style="list-style-type: none"> <li>• understand and explain how risk management is related to other issues in corporate finance,</li> <li>• critically assess different motivations for corporate risk management,</li> <li>• understand and critically assess different risk measures and how they are applied in practice,</li> <li>• understand and explain how international risks can be managed and how the management of international risks is related to various economic parity conditions,</li> <li>• understand, analyze and critically apply measures and methods to manage interest rate risk,</li> <li>• understand, analyze and critically apply measures and methods to manage credit risk,</li> <li>• understand, analyze and critically apply hedging strategies for commodity price risk.</li> </ul>	<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Financial Risk Management (Lecture)</b> <i>Contents:</i> <ol style="list-style-type: none"> <li>1. Introduction</li> <li>2. Risk Management: Motivation and Strategies</li> <li>3. Managing Interest Rate Risk</li> <li>4. Managing Credit Risk</li> <li>5. Managing International Risks</li> <li>6. Managing Commodity Price Risk</li> </ol> <p>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.</p>	2 WLH
<b>Course: Financial Risk Management (Tutorial)</b> <i>Contents:</i> In the accompanying practice sessions students deepen and broaden their knowledge from the lectures.	2 WLH
<b>Examination: Written examination (90 minutes)</b>	6 C
<b>Examination requirements:</b> <ul style="list-style-type: none"> <li>• Demonstrate a profound knowledge of how risk management is related to other issues in corporate finance.</li> <li>• Document an understanding of viable reasons for corporate risk management and how corporate risk management can create value.</li> <li>• Demonstrate the ability to analyze and apply different risk measures.</li> </ul>	

<ul style="list-style-type: none"> <li>• Show a profound understanding of methods and techniques used to manage international risks, interest rate risk, credit risk, and commodity price risk.</li> </ul>	
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<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.WIWI-BWL.0001 Corporate Finance
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Olaf Korn
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 2 - 3
<b>Maximum number of students:</b> not limited	

<b>Georg-August-Universität Göttingen</b> <b>Modul M.WIWI-BWL.0006: Seminar in Finanzwirtschaft</b> <i>English title: Seminar in Finance</i>		6 C 2 SWS
<b>Lernziele/Kompetenzen:</b> Mit dem erfolgreichen Abschluss des Moduls haben die Studierenden folgende Kompetenzen erworben: <ul style="list-style-type: none"> <li>• sie können die Lösung für eine komplexe, übergreifende Fragestellung mit finanzwirtschaftlichem Schwerpunkt eigenständig erarbeiten und sind in der Lage, das erworbene Wissen schriftlich und mündlich sachgerecht zu kommunizieren,</li> <li>• sie können ein Projekt erfolgreich managen und sind in der Lage eine Arbeitsgruppe zu koordinieren,</li> <li>• sie können von anderen erarbeiteten Lösungen der Fragestellung auf ihre zentralen Aspekte reduzieren und kritisch kommentieren,</li> <li>• sie können zu einer durch Referate angestoßenen Diskussion durch eigene qualifizierte Beiträge beitragen.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 28 Stunden Selbststudium: 152 Stunden
<b>Lehrveranstaltung: Seminar in Finanzwirtschaft (Seminar)</b> <i>Inhalte:</i> Inhalt des Seminars ist die projektbezogene Erarbeitung einer Lösung für eine übergreifende, komplexe Problemstellung mit finanzwirtschaftlichem Schwerpunkt. Genaue Inhalte und Themen können von Semester zu Semester wechseln und werden zum Ende des vorangehenden Semesters bekannt gegeben.		2 SWS
<b>Prüfung: Hausarbeit (max. 25 Seiten) mit Präsentation (ca. 45 Minuten)</b> <b>Prüfungsvorleistungen:</b> Aktive Teilnahme am Seminar.		6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Nachweis der Fähigkeit, eine komplexe finanzwirtschaftliche Fragestellung zu strukturieren und in verschiedene Teilfragen zu zerlegen.</li> <li>• Nachweis der Fähigkeit, eigenständige Lösungen der finanzwirtschaftlichen Fragestellung zu entwickeln und umzusetzen sowie diese zu kommunizieren.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> M.WIWI-BWL.0001 Finanzwirtschaft M.WIWI-BWL.0008 Derivate	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Olaf Korn	
<b>Angebotshäufigkeit:</b> jedes Sommersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 2 - 3	
<b>Maximale Studierendenzahl:</b> 16		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul M.WIWI-BWL.0008: Derivate</b></p> <p><i>English title: Derivatives</i></p>	<p>6 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>Nach dem erfolgreichen Abschluss des Moduls haben die Studierenden folgende Kompetenzen erworben:</p> <ul style="list-style-type: none"> <li>• sie besitzen vertiefte Kenntnisse über die verschiedenen Formen von Derivaten, insbesondere deren Ausgestaltung, Handel und Bedeutung,</li> <li>• sie können verschiedene Bewertungsansätze für Derivate (Duplikationsprinzip, Hedgingprinzip, Risikoneutrale Bewertung) verstehen und interpretieren,</li> <li>• sie verstehen die der Bewertung von Derivaten zugrundeliegende ökonomische Argumentation und sind in der Lage diese kritisch reflektierend zu bewerten,</li> <li>• sie verstehen die für die Bewertung und das Risikomanagement von Derivaten erforderlichen mathematisch-statistischen Verfahren und Kennzahlen und können diese anwenden,</li> <li>• sie sind in der Lage auch komplexe Derivate adäquat zu analysieren und selbständig computergestützt zu bewerten.</li> </ul>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden</p> <p>Selbststudium: 124 Stunden</p>
<p><b>Lehrveranstaltung: Derivate</b> (Vorlesung)</p> <p><i>Inhalte:</i></p> <ol style="list-style-type: none"> <li>1. Einführung             <ol style="list-style-type: none"> <li>1.1. Begriffliche Grundlagen</li> <li>1.2. Grundidee der Derivatebewertung</li> </ol> </li> <li>2. Forwards und Futures             <ol style="list-style-type: none"> <li>2.1. Arbitragefreie Terminpreise</li> <li>2.2. Forwards versus Futures</li> </ol> </li> <li>3. Optionen             <ol style="list-style-type: none"> <li>3.1. Grundlagen</li> <li>3.2. Verteilungsfreie Wertgrenzen</li> <li>3.3. Arbitrageorientierte Bewertung</li> </ol> </li> <li>4. Risikomanagement von Derivatepositionen             <ol style="list-style-type: none"> <li>4.1. Optionssensitivitäten</li> <li>4.2. Risikosteuerung</li> <li>4.3. Marktfriktionen und gleichgewichtsorientierte Bewertung</li> </ol> </li> </ol>	<p>2 SWS</p>

Die Erarbeitung des Vorlesungsstoffes erfolgt z.T. im Selbststudium auf Basis von Vorlesungsaufzeichnungen.		
<b>Lehrveranstaltung: Derivate</b> (Übung) <i>Inhalte:</i> Im Rahmen der begleitenden Übung vertiefen und erweitern die Studierenden die in der Vorlesung erworbenen Kenntnisse und Fähigkeiten		2 SWS
<b>Prüfung: Klausur (90 Minuten)</b>		6 C
<b>Prüfungsanforderungen:</b> <ul style="list-style-type: none"> <li>• Nachweis von Kenntnissen über die Ausgestaltungsformen von Derivaten, den Derivatehandel und die Bedeutung unterschiedlicher Produkte.</li> <li>• Nachweis von Kenntnissen über die verschiedenen Bewertungsansätze von Derivaten.</li> <li>• Nachweis über die Fähigkeit zur kritischen Analyse von Bewertungsmodellen und ihrer Annahmen.</li> <li>• Nachweis von Kenntnissen über die sich aus Bewertungsmodellen ergebenden Verfahren zum Risikomanagement von Derivaten und deren Anwendung.</li> <li>• Fähigkeit zur eigenständigen komplexer Derivatepositionen und zur Ermittlung von modellbasierten Werten.</li> </ul>		
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Grundkenntnisse aus finanzwirtschaftlichen Veranstaltungen im Bachelorstudium	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Olaf Korn	
<b>Angebotshäufigkeit:</b> jedes Wintersemester	<b>Dauer:</b> 1 Semester	
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 3	
<b>Maximale Studierendenzahl:</b> nicht begrenzt		

<p><b>Georg-August-Universität Göttingen</b></p> <p><b>Modul M.WIWI-BWL.0023: Performance Management</b></p> <p><i>English title: Performance Management</i></p>	<p>6 C 4 SWS</p>
<p><b>Lernziele/Kompetenzen:</b></p> <p>Mit Abschluss haben die Studierenden die konzeptionellen Grundlagen der wesentlichen Kennzahlen im Bereich der wertorientierten Unternehmensführung kennengelernt. Durch die Kombination von wissenschaftlichen Kenntnissen und praxisnahen Inhalten haben die Studierenden Kenntnis über die positiven und negativen Wirkungen von Instrumenten des Value Based Managements erlangt. Des Weiteren haben die Studierenden Kenntnisse über Ansätze zur Messung von Nachhaltigkeit in der Unternehmenssteuerung erworben.</p>	<p><b>Arbeitsaufwand:</b></p> <p>Präsenzzeit: 56 Stunden Selbststudium: 124 Stunden</p>
<p><b>Lehrveranstaltung: Performance Management (Vorlesung)</b></p> <p><i>Inhalte:</i></p> <p>Die Veranstaltung befasst sich mit wesentlichen Aspekten des Performancemanagements unternehmerischer Aktivitäten mit dem Fokus auf einer wertorientierten Perspektive ergänzt durch die zunehmend wichtiger werdende Nachhaltigkeitsperspektive. Die Veranstaltung ist in fünf 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. Ein weiterer Fokus wird auf die Messung der Nachhaltigkeit im Unternehmen gelegt. Abschließend erfolgt eine Einbettung der vorgestellten Ansätze in die Ausgestaltung von Performance Management Systemen.</p>	<p>2 SWS</p>
<p><b>Lehrveranstaltung: Performance Management (Übung)</b></p> <p><i>Inhalte:</i></p> <p>Die Übung dient dazu die Konzepte der wertorientierten Unternehmensführung auf praktische Fragestellungen anzuwenden, indem Übungsaufgaben gelöst und die Inhalte an praktischen Beispielen diskutiert werden. Im Sinne eines breiteren Einstiegs beginnt die Übung mit einer Abgrenzung der verschiedenen Stakeholdergruppen, um sich im Folgenden stärker auf die Shareholder-orientierten Inhalte der Unternehmensbewertung und deren Eignung für ein wertorientiertes Steuerungssystem zu diskutieren. Daraufhin werden traditionelle Kennzahlenkonzepte vorgestellt und mögliche Nachteile aufgezeigt. Auf dieser Basis werden die methodischen Grundlagen von wertorientierten Kennzahlen erörtert und deren Potentiale aufgezeigt. Den Gedanken der Stakeholder Orientierung wieder aufnehmend werden die Eigenschaften von Nachhaltigkeitskennzahlen genauer betrachtet. Zum Abschluss wird die Eignung der ganzheitlichen Implementierung von Value Based Management diskutiert.</p>	<p>2 SWS</p>
<p><b>Prüfung: Klausur (90 Minuten)</b></p>	<p>6 C</p>
<p><b>Prüfungsanforderungen:</b></p>	

Nachweis von Kenntnissen der Konzepte, Dimensionen und Grenzen der Kapitalmarkt- und Bilanz-orientierten Performancemessung, des Value-Based Managements sowie von Nachhaltigkeitskennzahlen durch Nennen, Erläutern und Berechnen in entsprechenden Aufgaben. Außerdem das Anwenden des erworbenen Wissens auf praxisnahe Aufgabenstellungen.	
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<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> Grundkenntnisse in Controlling
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Michael Wolff
<b>Angebotshäufigkeit:</b> jedes Wintersemester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 2
<b>Maximale Studierendenzahl:</b> nicht begrenzt	



<b>Georg-August-Universität Göttingen</b> <b>Modul M.WIWI-BWL.0034: Logistik- und Supply Chain Management</b> <i>English title: Logistics and Supply Chain Management</i>		6 C 3 SWS
<b>Lernziele/Kompetenzen:</b> Die Studierenden: <ul style="list-style-type: none"> <li>• kennen die Teilbereiche und Funktionen der Logistik sowie des Supply Chain Managements und können diese klassifizieren,</li> <li>• kennen den Begriff „Standortplanung“, können dessen Teilgebiete definieren und verschiedene OR-Modelle und Verfahren zur Standortbestimmung anwenden,</li> <li>• können das klassische Transportproblem erläutern und kennen dessen graphentheoretische Grundlagen,</li> <li>• kennen verschiedene Lösungsalgorithmen für das Transportproblem und können diese auch auf Sonderformen des klassischen Transportproblems anwenden,</li> <li>• kennen die Ausgestaltungsformen von Supply Chains und das SCOR-Modell,</li> <li>• können Produkt- und Prozessdesign voneinander abgrenzen,</li> <li>• kennen mögliche Formen der Vertragsgestaltung im Supply Chain Management,</li> <li>• kennen die verschiedenen Modelle der Bestellplanung und die Bestellregeln,</li> <li>• können statische Lagerhaltungsmodelle interpretieren und anwenden,</li> <li>• können dynamische Modelle voneinander abgrenzen und anwenden.</li> </ul>		<b>Arbeitsaufwand:</b> Präsenzzeit: 42 Stunden Selbststudium: 138 Stunden
<b>Lehrveranstaltung: Logistik- und Supply Chain Management (Vorlesung)</b> <i>Inhalte:</i> 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
<b>Lehrveranstaltung: Logistik- und Supply Chain Management (Übung)</b>		1 SWS
<b>Prüfung: Klausur (90 Minuten)</b> <b>Prüfungsanforderungen:</b> Die Studierenden weisen in der Prüfung Kenntnisse in den folgenden Bereichen nach: <ul style="list-style-type: none"> <li>• Grundlagen logistischer Problemstellungen</li> <li>• Standortplanung</li> <li>• Transportplanung</li> <li>• Supply Chain Management</li> <li>• Lagerhaltungsmodelle</li> <li>• Anwendung der vorgestellten OR-Modelle und Algorithmen auf die Problemstellungen der obigen Teilbereiche</li> </ul>		6 C
<b>Zugangsvoraussetzungen:</b> keine	<b>Empfohlene Vorkenntnisse:</b> M.WIWI-BWL.0024 Unternehmensplanung	
<b>Sprache:</b> Deutsch	<b>Modulverantwortliche[r]:</b> Prof. Dr. Matthias Klumpp	

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<b>Angebotshäufigkeit:</b> jedes 4. Semester	<b>Dauer:</b> 1 Semester
<b>Wiederholbarkeit:</b> zweimalig	<b>Empfohlenes Fachsemester:</b> 1 - 4
<b>Maximale Studierendenzahl:</b> nicht begrenzt	

<b>Georg-August-Universität Göttingen</b> <b>Module M.WIWI-BWL.0133: Banking Supervision</b>	6 C 2 WLH
<b>Learning outcome, core skills:</b> After a successful completion of the course students are able to: <ul style="list-style-type: none"> <li>• understand and explain how banking supervision has developed over time and how it differs across jurisdictions,</li> <li>• understand, explain and critically apply standard measures and methods of banking supervision,</li> <li>• understand and explain the Euro area banking union,</li> <li>• understand, explain and critically apply key concepts in banking regulation,</li> <li>• understand, explain and critically apply key measures and methods to assess the risks of financial institutions,</li> <li>• understand and explain micro-and macroprudential supervision and their differences.</li> </ul>	<b>Workload:</b> Attendance time: 28 h Self-study time: 152 h
<b>Course: Banking Supervision (Lecture)</b> <i>Contents:</i> <ol style="list-style-type: none"> <li>1. Introduction (e.g. banking structure)</li> <li>2. Foundations of banking supervision             <ul style="list-style-type: none"> <li>• Historical developments</li> <li>• Comparison across different jurisdictions</li> </ul> </li> <li>3. Banking Union – SSM</li> <li>4. Banking Regulation             <ul style="list-style-type: none"> <li>• Basel III, CRDIV/CRR</li> <li>• ASFR model by Gordy</li> <li>• Further requirements on banks</li> </ul> </li> <li>5. SSM Guide on banking supervision             <ul style="list-style-type: none"> <li>• How is banking supervision applied?</li> </ul> </li> <li>6. Risk Analysis             <ul style="list-style-type: none"> <li>• Stress testing</li> <li>• Bank Rating</li> </ul> </li> <li>7. Microprudential versus macroprudential supervision</li> </ol>	2 WLH
<b>Examination: Written examination (90 minutes)</b>	6 C
<b>Examination requirements:</b> <ul style="list-style-type: none"> <li>• Document an understanding how banking supervision has developed over time and how it differs across jurisdictions</li> <li>• Demonstrate a profound knowledge of standard measures and methods of banking supervision</li> <li>• Show an understanding of the Euro area banking union</li> <li>• Demonstrate the ability to explain and to some extent to apply key concepts in banking regulation</li> </ul>	

<ul style="list-style-type: none"> <li>• Document the knowledge to apply key measures and methods to assess the risks of financial institutions and to interpret the obtained results appropriately</li> <li>• Document an understanding of micro-and macroprudential supervision and their differences</li> </ul>	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.WIWI-BWL.0001 Corporate Finance M.WIWI-BWL.0004 Financial Risk Management
<b>Language:</b> English	<b>Person responsible for module:</b> Dr. Philipp Koziol
<b>Course frequency:</b> each winter semester	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 3
<b>Maximum number of students:</b> not limited	

<b>Georg-August-Universität Göttingen</b>		6 C 2 WLH
<b>Module M.WIWI-BWL.0134: Panel Data Analysis in Marketing</b>		
<b>Learning outcome, core skills:</b> Panel data refers to observations from different individuals or units (consumers, stores, products, etc.) over several time periods (days, weeks, months, etc.). After successful attendance the students will understand the methodological principles of panel data analysis, especially in the context of consumer behavior and marketing-mix models. Further, they will be able to conduct own panel data analyses using the statistical programming language R.		<b>Workload:</b> Attendance time: 28 h Self-study time: 152 h
<b>Course: Panel Data Analysis in Marketing (Lecture with exercise)</b> <i>Contents:</i> <ul style="list-style-type: none"> <li>• Introduction to R</li> <li>• Refreshment in Regression Analysis</li> <li>• Fixed Effects Models in Marketing</li> <li>• Random Effects Models in Marketing</li> <li>• Dynamic Panel Models in Marketing</li> </ul>		2 WLH
<b>Examination: Term Paper (max. 6000 words)</b>		6 C
<b>Examination requirements:</b> A self-conducted empirical project. Students will be provided with empirical data, but are welcome to analyze own projects. Students are advised to use the statistical programming language R, but can be allowed to use different statistics software in exceptional cases.  Theoretical, methodological and empirical elaboration of a selected topic in panel data analysis with focus on consumer behavior and/or marketing-mix modeling.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Basics in Hypothesis testing & Regression analysis  Previous knowledge in R is not required	
<b>Language:</b> English	<b>Person responsible for module:</b> Ossama Elshiewy	
<b>Course frequency:</b> each summer semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 2 - 4	
<b>Maximum number of students:</b> 25		

<b>Georg-August-Universität Göttingen</b>		6 C 4 WLH
<b>Module M.WIWI-QMW.0002: Advanced Statistical Inference (Likelihood &amp; Bayes)</b>		
<b>Learning outcome, core skills:</b> Upon completion of the module, the students have acquired the following competencies: <ul style="list-style-type: none"> <li>• foundations and general properties of likelihood-based inference in statistics,</li> <li>• bayesian approaches to statistical learning and their properties,</li> <li>• implementation of both approaches in statistical software using appropriate numerical procedures.</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Advanced Statistical Inference (Likelihood &amp; Baye) (Lecture)</b> <i>Contents:</i> The likelihood function and likelihood principles, maximum likelihood estimates and their properties, likelihood-based tests and confidence intervals (derived from Wald, score, and likelihood ratio statistics), expectation maximization algorithm, Bootstrap procedures (estimates for the standard deviation, the bias and confidence intervals), Bayes theorem, Bayes estimates, Bayesian credible intervals, prior choices, computational approaches for Bayesian inference, model choice, predictions		2 WLH
<b>Course: Advanced Statistical Inference (Likelihood &amp; Bayes) (Exercise)</b> <i>Contents:</i> The likelihood function and likelihood principles, maximum likelihood estimates and their properties, likelihood-based tests and confidence intervals (derived from Wald, score, and likelihood ratio statistics), expectation maximization algorithm, Bootstrap procedures (estimates for the standard deviation, the bias and confidence intervals), Bayes theorem, Bayes estimates, Bayesian credible intervals, prior choices, computational approaches for Bayesian inference, model choice, predictions		2 WLH
<b>Examination: Written examination (90 minutes) or oral examination (approx. 20 minutes)</b>		6 C
<b>Examination requirements:</b> The students demonstrate their general understanding of likelihood-based and Bayesian inference for different types of applications and research questions. They know about the advantages and disadvantages as well as general properties of both approaches, can critically assess the appropriateness for specific problems, and can implement them in statistical software. The exam covers contents of both the lecture and the exercise class.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> none	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Thomas Kneib	
<b>Course frequency:</b> every year	<b>Duration:</b> 1 semester[s]	

<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 2
<b>Maximum number of students:</b> not limited	
<b>Additional notes and regulations:</b> The actual examination will be published at the beginning of the semester.	

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module M.WIWI-QMW.0004: Econometrics I</b>		6 WLH
<b>Learning outcome, core skills:</b> 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.		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Econometrics I (Lecture)</b> <i>Contents:</i> The lecture covers the following topics:  <ol style="list-style-type: none"> <li>1. Introduction to the basic multiple regression model, model specification, OLS estimation, prediction and model selection, Multicollinearity and partial regression.</li> <li>2. The normal linear model, including maximum likelihood and interval estimation, hypothesis testing.</li> <li>3. Asymptotic properties of the OLS and (E)GLS estimators.</li> <li>4. Generalized linear model: GLS and EGLS estimators, properties of these, heteroskedastic and autocorrelated models, testing for heteroscedasticity and autocorrelation.</li> </ol>		2 WLH
<b>Course: Econometrics I (Exercise)</b> <i>Contents:</i> 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.		2 WLH
<b>Course: Econometrics I (Tutorial)</b> <i>Contents:</i> 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.		2 WLH
<b>Examination: Written examination (90 minutes)</b>		6 C
<b>Examination requirements:</b> The students demonstrate their understanding of basic econometric concepts. They show that they can apply these concepts to real economic problems.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Module B.WIWI-OPH.0006: Statistics and module B.WIWI-OPH.0002: Mathematics	
<b>Language:</b>	<b>Person responsible for module:</b>	



English	Prof. Dr. Helmut Herwartz
<b>Course frequency:</b> each semester	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 2
<b>Maximum number of students:</b> not limited	

<b>Georg-August-Universität Göttingen</b>		6 C
<b>Module M.WIWI-QMW.0005: Econometrics II</b>		4 WLH
<b>Learning outcome, core skills:</b> As the outcome of this advanced course the students are able to <ul style="list-style-type: none"> <li>• identify problems of estimation and inference arising due to stochastic regressors,</li> <li>• establish finite sample and asymptotic properties of estimators under the assumption that the data generating process contains stochastic regressors,</li> <li>• model simple univariate stationary and non-stationary time series processes,</li> <li>• carry out and interpret test results of unit root and cointegration tests,</li> <li>• set up, and estimate (over-, under-) identified simultaneous equation models,</li> <li>• model simple multivariate time series with possible cointegration,</li> <li>• implement estimators and analyze real world datasets with the R programming language.</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Econometrics</b> (Lecture) <i>Contents:</i> Stochastic regressors in linear econometric models; OLS, IV, 2SLS, GMM estimators; Dynamic linear econometric models: stationary stochastic processes, ARMA models, (testing) unit roots, (testing) cointegration, spurious regression; Simultaneous equation models: Identification, estimation (GLS, IV, 2SLS, 3SLS, ILS) Vector autoregressive and error correction models: Interpretation, estimation, inference.		2 WLH
<b>Course: Econometrics II</b> (Exercise) <i>Contents:</i> Exercises deepening concepts from the lecture, and demonstrating practical applications. Simulations and data analysis exercises using the R programming language.		2 WLH
<b>Examination: Written examination (90 minutes)</b>		6 C
<b>Examination requirements:</b> The students demonstrate their understanding of advanced econometric concepts. They show that they can apply these concepts to real economic problems.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> M.WIWI-QMW.0004 Econometrics I	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Helmut Herwartz	
<b>Course frequency:</b> each summer semester	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 2 - 3	
<b>Maximum number of students:</b> not limited		

<b>Georg-August-Universität Göttingen</b>		6 C 4 WLH
<b>Module M.WIWI-QMW.0009: Introduction to Time Series Analysis</b>		
<b>Learning outcome, core skills:</b> The students: <ul style="list-style-type: none"> <li>• learn concepts and techniques related to the analysis of time series and forecasting,</li> <li>• gain a solid understanding of the stochastic mechanisms underlying time series data,</li> <li>• learn how to analyse time series using statistical software packages and how to interpret the results obtained.</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Introduction to Time Series Analysis (Lecture)</b> <i>Contents:</i> 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
<b>Course: Introduction to Time Series Analysis (Tutorial)</b> <i>Contents:</i> 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
<b>Examination: Written examination (90 minutes)</b>		6 C
<b>Examination requirements:</b> 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.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.WIWI-OPH.0006 Statistics and M.WIWI-QMW.0004 Econometrics I	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Helmut Herwartz	
<b>Course frequency:</b> once a year	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 2 - 3	

<b>Maximum number of students:</b>	
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50	
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<b>Georg-August-Universität Göttingen</b>		6 C 4 WLH
<b>Module M.WIWI-QMW.0012: Multivariate Time Series Analysis</b>		
<b>Learning outcome, core skills:</b> The students: <ul style="list-style-type: none"> <li>• learn concepts and techniques related to the analysis of multivariate time series and the forecasting thereof.</li> <li>• learn to characterize the dynamic interrelationship between the variables of dynamic systems,</li> <li>• learn to relate economic models with restrictions implied by its empirical counterpart,</li> <li>• learn how to analyse multivariate time series using by means of statistical software packages and to interpret the results obtained.</li> </ul>		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Multivariate Time Series Analysis (Lecture)</b> <i>Contents:</i> 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
<b>Course: Multivariate Time Series Analysis (Tutorial)</b> <i>Contents:</i> 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
<b>Examination: Written examination (90 minutes)</b>		6 C
<b>Examination requirements:</b> 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.		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> B.WIWI-OPH.0006 Statistics, M.WIWI-QMW.0004 Econometrics I, M.WIWI-QMW.0009 Introduction to Time Series Analysis	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Helmut Herwartz	
<b>Course frequency:</b> once a year	<b>Duration:</b> 1 semester[s]	
<b>Number of repeat examinations permitted:</b>	<b>Recommended semester:</b>	

twice

3 - 4

<b>Georg-August-Universität Göttingen</b>		6 C 4 WLH
<b>Module M.WIWI-VWL.0001: Advanced Microeconomics</b>		
<b>Learning outcome, core skills:</b> This course covers advanced microeconomic models. In this regard students are provided with the skills required to understand these models including advanced methods of calculus and basic proof techniques. Students learn how to formalize and analyze individual decision making and strategic interactions. They will get acquainted with models of individual choice under certainty and uncertainty. Students will be able to analyze decision problems of firms. They can distinguish between partial analysis of isolated markets and a general analysis considering mutual dependencies of markets. Finally, students will be able to formalize strategic interactions and to predict their theoretical outcomes based on a variety of solution concepts.		<b>Workload:</b> Attendance time: 56 h Self-study time: 124 h
<b>Course: Advanced Microeconomics (Lecture)</b> <i>Contents:</i> This course presents a formal treatment of microeconomic theory. <ol style="list-style-type: none"> <li>1. Rational choice under certainty</li> <li>2. Consumer theory</li> <li>3. Rational choice under uncertainty</li> <li>4. Partial equilibrium</li> <li>5. General equilibrium</li> <li>6. Game theory</li> </ol>		2 WLH
<b>Course: Advanced Microeconomics (Exercise)</b> <i>Contents:</i> The exercise deepens the understanding of concepts presented in the lecture. Students will receive problem sets, which they are requested to prepare at home. The solutions of these problem sets will be discussed in class.		2 WLH
<b>Examination: Written examination (90 minutes)</b>		6 C
<b>Examination requirements:</b> <ul style="list-style-type: none"> <li>• Demonstrate the capability to understand advanced economic models</li> <li>• Demonstrate the understanding of the main concepts of individual choice theory</li> <li>• Apply techniques developed in the lecture and in the exercise such as the method of Lagrange multipliers or the Edgeworth Box</li> <li>• Demonstrate the basic knowledge of the theory of partial and general equilibrium</li> <li>• Prove the ability to solve analytical exercises</li> <li>• Find the game theoretical solutions to strategic interactions</li> <li>• Conduct advanced calculations</li> </ul>		
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> BA level microeconomics and mathematics	
<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Claudia Keser Prof. Marcela Ibanez Diaz	

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<b>Course frequency:</b> each semester	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 2
<b>Maximum number of students:</b> not limited	



<b>Georg-August-Universität Göttingen</b> <b>Module M.WIWI-VWL.0041: Panel Data Econometrics</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b></p> <p>This course aims to study panel data econometric techniques in an intuitive and practical way and to provide students the skills and understanding to read and evaluate empirical literature and to carry out empirical research. The course is concerned with the application of econometric panel-data methods, including basic linear unobserved effects panel data models with exogenous and endogenous regressors; random effects and fixed effects methods for static and dynamic models and panel data methods for binary dependent variables.</p> <p>Students learn basic econometric terminology and estimation and test principles for efficient inference with panel data and the potential of panel data to deal with estimation biases related to unobserved heterogeneity in individual characteristics.</p> <p>Students read and understand project reports and journal articles that use the methods introduced in the course and to make use of the course content in their academic work, namely, in analyses that are part of their master's or PhD thesis.</p>	<p><b>Workload:</b></p> <p>Attendance time: 56 h</p> <p>Self-study time: 124 h</p>
<p><b>Course: Panel Data Econometrics (Lecture)</b></p> <p><i>Contents:</i></p> <p><i>Linear Panel Data Models</i></p> <p>1. Static Linear Panel Data Models</p> <p>    1.1 Introduction to Panel Data</p> <p>    1.2 Assumptions</p> <p>    1.3 Estimation and Testing</p> <p>        1.3.1 Pooled OLS</p> <p>        1.3.2 Random Effects Estimation</p> <p>        1.3.3 Fixed Effects Estimation. Testing for Serial Correlation</p> <p>        1.3.4 First-Differencing Estimation</p> <p>    1.4. Comparison of Estimators and Testing the Assumptions</p> <p>    1.5 Correlated Random Effects (CRE) or Mundlak's Approach</p> <p>2. Endogeneity and Dynamics in Linear Panel Data Models</p> <p>    2.1. Equivalence Between GMM 3SLS and Standard Estimators</p> <p>    2.2 Chamberlain's Approach to UE Models</p> <p>    2.3. RE and FE Instrumental Variables Methods</p> <p>    2.4. Hausman and Taylor Models</p> <p>    2.5. First Differencing and IV</p> <p>    2.6. Dynamic Panel Data Models. Estimation under Sequential Exogeneity</p> <p>3. Special Topics</p>	2 WLH

<p>3.1 Heterogeneous Panels</p> <p>3.2 Random Trend Models</p> <p>3.3 General Models with Specific Slopes</p> <p>3.4 Robustness of Standard Fixed Effects Estimators</p> <p>3.5 Testing for Correlated Random Slopes</p> <p><i>Non-linear Panel Data Models</i></p> <p>4. Panel Data Models for Discrete Variables</p> <p>4.1 Introduction. Binary Response Panel Data Models with Strictly Exogenous Variables</p> <p>4.2 Linear Probability Model</p> <p>4.3 Fixed versus Random Effects</p> <p>4.4 Other issues: Endogenous explanatory variables/Selection Bias</p> <p>The course is organized as a series of lectures complemented with tutorials.</p>	
<p><b>Course: Panel Data Econometrics (Tutorial)</b></p> <p><i>Contents:</i></p> <p>The computer software package STATA will be used for practical work.</p>	2 WLH
<p><b>Examination: Written examination (120 minutes)</b></p>	4 C
<p><b>Examination: Term Paper (max. 10 pages, based on the tutorial)</b></p>	2 C
<p><b>Examination requirements:</b></p> <p>After taking the course, students should be able to:</p> <ul style="list-style-type: none"> <li>• formulate static and dynamic econometric models for panel data on the basis of economic theories, recognise the reasons why panel data is a richer data framework than pure cross-section or pure time-series data,</li> <li>• translate models for cross-section and for time-series into panel data models,</li> <li>• use the computer software package STATA to estimate panel data models,</li> <li>• estimate parameter in panel data models using real datasets and test hypotheses by using STATA,</li> <li>• interpret and evaluate the results of empirical estimations of economic models, which is an important feature of the study and application of economics.</li> </ul>	
<p><b>Admission requirements:</b></p> <p>none</p>	<p><b>Recommended previous knowledge:</b></p> <p>Previous knowledge of intermediate econometrics is required.</p>
<p><b>Language:</b></p> <p>English</p>	<p><b>Person responsible for module:</b></p> <p>Prof. Dr. Inmaculada Martinez-Zarzoso</p>
<p><b>Course frequency:</b></p> <p>each summer semester</p>	<p><b>Duration:</b></p> <p>1 semester[s]</p>
<p><b>Number of repeat examinations permitted:</b></p> <p>twice</p>	<p><b>Recommended semester:</b></p> <p>2 - 4</p>

<b>Maximum number of students:</b>	
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30	
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<b>Georg-August-Universität Göttingen</b> <b>Module M.WIWI-VWL.0092: International Trade</b>	6 C 4 WLH
<p><b>Learning outcome, core skills:</b>          After a successful completion of the course students have achieved following competences:</p> <ul style="list-style-type: none"> <li>• give an overview of the core theoretical concepts explaining international trade patterns by means of various sources of trade flows like different technologies or factor endowments,</li> <li>• understand and apply the concepts of comparative and absolute advantage,</li> <li>• analyze the effects of international trade on the trading partners with respect to (i) their production and overall welfare, (ii) the reallocation of resources in the production process, (iii) the change in nominal factor prices, and (iv) on changes in the purchasing power of consumers,</li> <li>• evaluate and critically reflect the gains and losses of international trade,</li> <li>• evaluate the consequences of different trade policies like tariffs and subsidies,</li> <li>• understand, summarize, and critically assess recent approaches to explain international trade patterns that are observed today based on scientific publications.</li> </ul>	<p><b>Workload:</b>          Attendance time:          56 h          Self-study time:          124 h</p>
<p><b>Course: International Trade (Lecture)</b>  <i>Contents:</i></p> <ol style="list-style-type: none"> <li>1. <b>The Ricardian model</b>          Mathematical and graphical analysis of the trade equilibrium in a neoclassical model explaining inter-industry trade with one production factor and (i) two goods, as well as (ii) a continuum of goods. Analysis of the trade effects on production and consumption, wages and overall welfare gains from trade.</li> <li>2. <b>The Heckscher-Ohlin model</b>          Mathematical and graphical analysis of the trade equilibrium in a neoclassical model with two production factors. Analysis of trade effects on production and consumption, factor prices, and of distributional effects as implied by the Stolper-Samuelson Theorem. Analysis of the effects of changes in resource endowments as implied by the Rybczynski Theorem. Empirical test of the Heckscher-Ohlin model.</li> <li>3. <b>The neoclassical trade model in higher dimensions</b>          Generalization of the Heckscher-Ohlin model to many production factors and goods by means of the Heckscher-Ohlin-Vanek model. Empirical test of Heckscher-Ohlin-Vanek model. Derivation of the specific-factors model with more production factors than goods and analysis of changes in goods prices and factor endowments.</li> <li>4. <b>Imperfect competition in international trade</b>          Mathematical and graphical analysis of the Krugman model with increasing returns to scale and monopolistic competition as an explanation of intra-industry trade. Non-formal extensions of the Krugman model with (i) consumer CES preferences and (ii) heterogeneous technologies across firms, and the Melitz model. Formal</li> </ol>	2 WLH

<p>derivation of the empirical Gravity equation based on the monopolistic competition model.</p> <p><b>5. Trade policy under perfect competition</b> Graphical analysis of the introduction of tariffs and quotas to the trade equilibrium under perfect competition on economic welfare. Analysis of partial and general equilibrium effects.</p> <p><b>6. Trade policy under imperfect competition</b> Graphical analysis of the introduction of tariffs and quotas to the trade equilibrium under monopolistic market power on economic welfare. Formal derivation of the median voter model to analyze political decisions on the usage of trade policies.</p> <p><b>7. Project work</b> Recent empirical and theoretical contributions from the academic literature on international trade within the frame of student presentations.</p>		
<p><b>Course: International Trade (Exercise)</b> <i>Contents:</i> In the accompanying practice session students deepen and broaden their knowledge from the lectures.</p>		2 WLH
<p><b>Examination: Written examination (90 minutes)</b> <b>Examination prerequisites:</b> Presentation of a group work (approx. 20 min )</p>		6 C
<p><b>Examination requirements:</b></p> <ul style="list-style-type: none"> <li>• Demonstrate a profound knowledge of the core theoretical concepts in international trade,</li> <li>• show the ability to analyze the welfare and distributional effects of international trade by means of graphical and mathematical tools,</li> <li>• show the ability to analyze the effects of trade policies,</li> <li>• students should be able to assess the theoretical models with respect to empirical applications.</li> </ul>		
<p><b>Admission requirements:</b> none</p>	<p><b>Recommended previous knowledge:</b> Microeconomics</p>	
<p><b>Language:</b> English</p>	<p><b>Person responsible for module:</b> Prof. Dr. Udo Kreickemeier</p>	
<p><b>Course frequency:</b> each semester</p>	<p><b>Duration:</b> 1 semester[s]</p>	
<p><b>Number of repeat examinations permitted:</b> twice</p>	<p><b>Recommended semester:</b> 1 - 2</p>	
<p><b>Maximum number of students:</b> not limited</p>		
<p><b>Additional notes and regulations:</b> The courses "M.WIWI-VWL.0003: Reale Außenwirtschaft" and "M.WIWI-VWL.0092: International Trade" are equal. Students can conclude only one of these courses.</p>		

<b>Georg-August-Universität Göttingen</b> <b>Module M.WIWI-VWL.0128: Deep Determinants of Growth and Development</b>	6 C 2 WLH
<b>Learning outcome, core skills:</b> After a successful participation, students have a deeper understanding of the mechanisms that lead to long-run economic growth and development. They learn about the forces that are linked to economic development like governance, corruption, institutions, democracy, inequality, culture, and social capital.	<b>Workload:</b> Attendance time: 28 h Self-study time: 152 h
<b>Course: Deep Determinants of Growth and Development (Lecture)</b> <i>Contents:</i> In this course, we will study long-run trends in economic development. We will analyze questions such as <ul style="list-style-type: none"> <li>• Why are some countries richer than others?</li> <li>• Why is a country today richer than several generations ago?</li> <li>• How can historical events affect the economy today?</li> <li>• What are the mechanisms that lead to the transition from stagnation towards sustained growth?</li> </ul> <b>Contents:</b> <ol style="list-style-type: none"> <li>1. Governance</li> <li>2. Property Rights</li> <li>3. Inequality</li> <li>4. Institutional Change</li> <li>5. Culture and Social Capital</li> </ol> <b>Literature:</b> The course is based upon selected research articles. Further information on the relevant literature is announced in the syllabus.	2 WLH
<b>Examination: Oral exam (ca. 20 minutes) or written exam (90 minutes)</b>	6 C
<b>Examination requirements:</b> Demonstrate: <ul style="list-style-type: none"> <li>• a profound knowledge of the deep determinants of long-run development,</li> <li>• a deep understanding of the fundamental causes and consequences of long-run economic growth,</li> <li>• the ability to solve problems in a verbal, graphical and analytical manner.</li> </ul>	
<b>Admission requirements:</b> none	<b>Recommended previous knowledge:</b> Macroeconomics, Mathematics for Economists, Economic Growth, Econometrics as taught in the Bachelor courses

<b>Language:</b> English	<b>Person responsible for module:</b> Prof. Dr. Holger Strulik
<b>Course frequency:</b> irregular	<b>Duration:</b> 1 semester[s]
<b>Number of repeat examinations permitted:</b> twice	<b>Recommended semester:</b> 1 - 4