TECHNISCHE UNIVERSITÄT WIEN

Bachelor

Master

Doktorat

Universitäts-lehrgang

Studienplan (Curriculum) für das

Masterstudium Interdisciplinary Mathematics UE 066 393

Technische Universität Wien

Beschluss des Senats der Technischen Universität Wien

am 30. November 2020

Gültig ab 1. Oktober 2021

Inhaltsverzeichnis

1. Grundlage und Geltungsbereich (Basis and Scope)

Der vorliegende Studienplan definiert und regelt das ingenieurwissenschaftliche, englischsprachige Masterstudium *Interdisciplinary Mathematics* an der Technischen Universität Wien. Es basiert auf dem Universitätsgesetz 2002 – UG (BGBl. I Nr. 120/2002 idgF.) – und den *Studienrechtlichen Bestimmungen der Satzung der Technischen Universität Wien* in der jeweils geltenden Fassung. Die Struktur und Ausgestaltung dieses Studiums orientieren sich am Qualifikationsprofil gemäß Abschnitt 2. Die diesen gesetzlichen Rahmenbedingungen für Studien an der Technischen Universität Wien entsprechenden Abschnitte sind in deutscher Sprache ausgeführt, während der Rest des Studienplans in englischer Sprache abgefasst ist. Für Lehrveranstaltungen und Prüfungen, die an den Partneruniversitäten Università degli Studi dell'Aquila (L'Aquila) in Italien und Universitat Autònoma de Barcelona (UAB) in Spanien abgehalten werden, gelten deren Vorschriften.

The present curriculum defines and regulates the part of the natural science master program „Interdisciplinary Mathematics“ offered at Technische Universität Wien. It is based on the University Law BGBl. I Nr. 120/2002 (UG) and the regulations of the statutes of Technische Universität Wien as amended; the relevant sections 7–12 containing these legal conditions for studies at Technische Universität Wien are executed in German while the rest of the curriculum is written in English. For the courses and exams held at the partner universities Università degli Studi dell'Aquila (L'Aquila), Italy, and Universitat Autònoma de Barcelona (UAB), Spanien their rules apply. Structure and design of this *English* curriculum are based on the qualification profile according to section 2.

2. Qualifikationsprofil (Qualifications profile)

Mathematical modeling refers to the use of mathematics and related computational tools to bring real-world, challenging and important socio-economic and industrial problems into a form simple enough so that a good solution can be found in reasonable time, while keeping the relevant features of the problem. Constructing models requires advanced knowledge of mathematical theory, methods for solving problems which are effective and efficient, computational tools at hand to be used, sound knowledge of the field of application, and communicative skills to understand the important elements from experts in that field. Our master curriculum tries to put together all these elements to produce professionals able to work in different relevant fields with the highest intellectual level and state-of-the-art tools.

Effective modeling and simulation is an art that requires a lot of practice, so that problem solving, project development and teamwork are aspects that should be highlighted in any training program. On the other hand, the abstraction behind the specific application is necessary to realize that the same base tools can be applied, with the needed changes, to very different situations in various fields of engineering.

This proposed joint master curriculum involves five European universities: Università degli Studi dell'Aquila (L'Aquila), Technische Universität Wien (TU Wien), Universitat Autònoma de Barcelona (UAB), Catalonia, Spain, Technische Universität Hamburg (TU Hamburg), Germany, Université Côte d'Azur, France. All the specializations offered, which reflect fields of excellence of the participating centers, are related to mathematical modeling with applications to engineering. The graduate completing the proposed program is expected to feature the main qualities required nowadays from a mathematical modeler in engineering, namely being capable of developing models and promoting innovative processes.

This master curriculum is more wide-ranging when compared to traditional master programs in *Technical Mathematics*, since it covers several methodological areas of mathematics that are shared by very diverse fields of applications in engineering, with a special focus on modern applications. Moreover, it addresses more directly to the solution of problems in engineering. The object of the course in general is to encourage open-minded flexibility in the approach to problem solving so as to enable the graduate to deal with problems which may be quite different to those encountered specifically during the course of study.

This master curriculum offers an actual integration of the program: it is not just a multiple degree program based on the local programs of the five partners. The diploma awarded is a joint one and the mobility is designed to contribute to the consistency of the curriculum instead of disturbing it. The use of the English language – the language common to science and technology – in all activities throughout the whole program contributes to the rapid integration of students among them and to that of students and teachers, without forgetting the important aspect of immersion in the local cultures.

The master program „Interdisciplinary Mathematics" provides in-depth, scientifically and methodically high-quality education aiming at lasting knowledge, which qualifies the graduates both for further qualification, especially in the context of a relevant doctoral degree program and for employment in, for example, the following fields of activity, and it makes them internationally competitive:

- Engineering companies involved in both consultant as well as research and development activities;
- Companies or public bodies for the management of services;
- Manufacturing industries that produce and integrate complex systems;
- Companies that produce software dedicated to modeling and simulation;
- Institutes and research laboratories in the field of engineering, applied mathematics, math finance and applied physics.

Due to the professional requirements, the master curriculum „Mathematical Modelling in Engineering" conveys qualifications in the following categories.

Aufgrund der beruflichen Anforderungen werden im Masterstudium *Interdisciplinary Mathematics* Qualifikationen hinsichtlich folgender Kategorien vermittelt.

Professional and methodological competencies:

Due to the richness of the mathematical applications and the diversity of the need for mathematical skills, in addition to sound basic mathematical knowledge, a focused education is an essential tool to specialize deeply on a specific area of application or to a specific methodological branch.

Students coming to Vienna to do their second semester at TU Wien, in their third semester may choose one of the following options as their topical focus:

- Computational Fluid Dynamics (TU Wien),
- Decision Making with Applications to Logistic (UAB);
- Cancer Modelling and Simulation (L'Aquila).

Students going to Hamburg to do their second semester at TU Hamburg instead, in their third semester may choose one of the following options as their topical focus:

- Computational Methods in Biomedical Imaging (TU Hamburg),
- Decision Stochastic Modelling in Neuroscience (Université Côte d'Azur);
- Modelling and Analysis of Epidemic Diseases (L'Aquila).

Depending on the chosen focus, the curriculum provides in-depth knowledge in several of the following areas:

- Functional analysis,
- Advanced analysis,
- Control systems,
- Dynamical systems and bifurcation theory,
- Partial differential equations,
- Numerical methods for ODEs and PDEs,
- Optimisation,
- Probability and stochastic processes,
- High performance computing,
- Mathematical models for collective behaviour,
- Fluid dynamics,
- Biomathematics,
- Systems biology,
- Logic systems,
- Medical imaging,
- Neuroscience,
- Modelling and control of networked distributed systems.

Cognitive and practical competencies:

The study conveys essential mathematical ways of thinking and working. These include in particular:

- recognition of structures, abstraction ability;
- logical and algorithmic procedure;
- ability to work independently on new subject-relevant questions, methods and (especially English-language) scientific literature;
- ability to document solutions and critically evaluate them;

- communication and presentation;
- first insights into the science business.

As the whole program is taught in English and there is a compulsory mobility, students also acquire foreign language skills: predominantly in English, but also in Italian, German, French, and in some cases Catalan.

Social competencies and self-competencies:
Important competences are:

- scientific reasoning;
- adaptability and willingness to critically and intensively deal with other sciences, which often form the context of a project;
- presentation of results and hypotheses;
- accuracy and endurance.

3. Dauer und Umfang (Duration and Scope)

The total work effort for the master curriculum „Interdisciplinary Mathematics“ is 120 ECTS-points[1]. For full time students, this corresponds to a foreseen study duration of 4 semesters.

4. Zulassung zum Masterstudium (Admission to the master program)

The admission to the master program „Interdisciplinary Mathematics“ requires the completion of a thematically relevant bachelor study at a recognized University or University of Applied Studies. This qualification has to be verified by the Università degli Studi dell’Aquila.

Thematically relevant bachelor studies at Technische Universität Wien, for example, are the bachelor programs „Technical Mathematics“, „Statistics and Mathematics in Economics“, „Financial and Actuarial Mathematics“, „Technical Physics“, „Mechanical Engineering“, and „Electrical Engineering and Information Technology“.

The master program has a limitation on the number of students that are admitted every year to the first semester. The applications of students that satisfy the formal qualification for this master program are then subject to a selection procedure, based on one linear ranking of these applications. All five partner universities participate in this selection procedure.

Students can only register for this master program at TU Wien, if they are still keeping an active status of this very master program at the Università degli Studi dell’Aquila, where they passed the first semester.

[1]ECTS (European Credit Transfer System) points are a measure for the standard work effort of students, where one ECTS credit corresponds to the amount of work of 25 full hours of an „average student“. The standard work effort of one academic year is normalized at 60 ECTS credits.

5. Aufbau des Studiums (Structure of the curriculum)

Die Inhalte und Qualifikationen des Studiums werden durch *Module* vermittelt. Ein Modul ist eine Lehr- und Lerneinheit, welche durch Eingangs- und Ausgangsqualifikationen, Inhalt, Lehr- und Lernformen, den Regelarbeitsaufwand sowie die Leistungsbeurteilung gekennzeichnet ist. Die Absolvierung von Modulen erfolgt in Form einzelner oder mehrerer inhaltlich zusammenhängender *Lehrveranstaltungen*.

The contents and qualifications of this curriculum are conveyed in modules. A module is a teaching and learning unit, which is characterized by input and output qualifications, contents, teaching and learning forms, the standard work effort as well as the grading system. Mastering a module is done in form of individual or multiple, thematically related courses.

Prüfungsfächer und zugehörige Module (Examination fields and corresponding modules)

Das Masterstudium *Interdisciplinary Mathematics* gliedert sich in nachstehende Prüfungsfächer mit den ihnen zugeordneten Modulen.

The master program „Interdisciplinary Mathematics“ consists of the following examination fields and the following modules.

5.1. Semester 1 (WS) at Università degli Studi dell’Aquila

Module	ECTS
Advanced Real Analysis	6
Dynamical systems and bifurcation theory	6
Applied partial differential equations	6
Control systems	6
Mathematical Modelling of Continuum Media	3
Italian language and culture for foreigners (A1 level)	3
volume of semester 1	30

5.2. Semester 2 (SS) at Technische Universität Wien

Module	ECTS
Computer Programming and Parallel Computing	8
Numerical Methods for Ordinary Differential Equations	6
Numerical Methods for Partial Differential Equations	7
Elective module A	6
German (A1 level)	3
volume of semester 2	30

As Elective module A one of the following 3 modules has to be chosen:

- Numerical optimisation, 6,0
- Iterative solution of large systems, 6,0,
- Stationary processes and time series analysis, 6,0

It is strongly recommended to choose Module Numerical optimisation (6,0), especially for those students, who continue their study at the Universitat Autònoma de Barcelona with the Topical Focus „Decision Making with Applications to Logistic“.

Courses in the compulsory module „German A1“ (3 ECTS):

- If students have already reached the A1-level in German, this module may be replaced by any courses of choice („Freie Wahlfächer“) in the amount of 3 ECTS.

5.2.1. Semester 3 (WS) and 4 (SS) at Technische Universität Wien, Università degli Studi dell'Aquila, or Universitat Autònoma de Barcelona

The students have to choose one *Topical Focus* out of three options, in accordance with the capacity of the three universities TU Wien, Università degli Studi dell'Aquila, and Universitat Autònoma de Barcelona. The Topical Focus determines the university and the choice of courses to be taken.

Topical focus *Computational Fluid Dynamics* at Technische Universität Wien

Module	ECTS
Continuum and kinetic modelling with PDEs	6
Computational fluid dynamics	5
CFD-codes and turbulent flows	6
Elective module B	6
Elective module C	7
Diploma thesis with diploma exam	30
total volume of study (incl. semester 1+2)	120

As „Elective module B“ one of the following 3 modules has to be chosen:

- Module Numerical simulation and scientific computing, 6,0,
- Module Multi-Physics, 6,0,
- Module High Performance Computing, 6,0

As „Elective module C“ one of the following 2 modules has to be chosen:

- Module Continuum models in semiconductor theory, 7,0,
- Module Stochastic analysis, 7,0,

Topical focus *Decision Making with Applications to Logistic* at Universitat Autònoma de Barcelona

Module	ECTS
Combinatorial optimisation	6
Logistic systems	6
Simulation and Bayesian networks	6
Decision Making in logistics	6
Case studies of optimisation problems in industry	6
Diploma thesis with diploma exam	30
overall volume of curriculum (incl. semester 1+2)	120

Topical focus *Cancer Modelling and Simulation* at the Università degli Studi dell'Aquila

Module	ECTS
Advanced Analysis	6
Biomathematics	6
Mathematical bio-fluid dynamics	6
Systems biology	6
Cancer genetics and biology for mathematical modelling	6
Diploma thesis with diploma exam	30
overall volume of curriculum (incl. semester 1+2)	120

5.3. Semester 2 (SS) at Technische Universität Hamburg

As an alternative to come to the TU Wien for the second semester, students can also go to the TU Hamburg for the second semester and then continue their studies at TU Hamburg, Université Côte d'Azur, or Università degli Studi dell'Aquila.

Module	ECTS
Numerical Methods for Ordinary Differential Equations	6
Iterative Solvers & Parallelization of Solvers	9
Variational Calculus	6
Probability Theory	6
German Language and Culture (A1 level)	3
volume of semester 2	30

5.3.1. Semester 3 (WS) and 4 (SS) at TU Hamburg, Université Côte d'Azur, or Università degli Studi dell'Aquila

The students have to choose one *Topical Focus* out of three options, in accordance with the capacity of the three universities TU Hamburg, Université Côte d'Azur, or Università degli Studi dell'Aquila. The Topical Focus determines the university and the choice of courses to be taken.

Topical focus *Computational Methods in Biomedical Imaging* at the TU Hamburg

Module	ECTS
Mathematical image processing	6
Computer tomography	6
Medical Imaging	6
Intelligent systems in medicine	6
Case studies in medical and biomedical applications	6
overall volume of curriculum (incl. semester 1+2)	120

Topical focus *Stochastic Modelling in Neuroscience* at the Université Côte d'Azur

Module	ECTS
Advanced stochastic calculus	6
Probabilistic numerical methods	6
Stochastic control	6
Stochastic models in neurocognition	6
Behavioral and congitive neuroscience	6
overall volume of curriculum (incl. semester 1+2)	120

Topical focus *Modelling and Analysis of Epidemic Diseases* at the Università degli Studi dell'Aquila

Module	ECTS
Advanced Analysis	6
Mathematical Modeling and Simulation in epidemics	6
Time Series and Prediction	6
Systems Biology	6
Modelling and control methods for infectious diseases	6
overall volume of curriculum (incl. semester 1+2)	120

5.4. Liste der an der TU Wien absolvierbaren Prüfungsfächer

CFD Codes and Turbulent Flows

CFD-codes and turbulent flows (6,0 ECTS)

Computational Fluid Dynamics

Computational fluid dynamics (5,0 ECTS)

Computer Programming and Parallel Computing

Computer programming and parallel computing (8,0 ECTS)

Continuum and Kinetic Modelling with PDEs

Continuum and kinetic modeling with PDEs (6,0 ECTS)

Elective Module A

Numerical optimisation (6,0 ECTS)
Iterative solution of large systems (6,0 ECTS)
Stationary processes and time series analysis (6,0 ECTS)

Elective Module B

Numerical simulation and scientific computing (6,0 ECTS)
Multi-Physics (6,0 ECTS)
High Performance Computing (6,0 ECTS)

Elective Module C

Continuum models in semiconductor theory (7,0 ECTS)
Stochastic analysis (7,0 ECTS)

German

German (3,0 ECTS)

Numerical Methods for Ordinary Differential Equations

Numerical Methods for Ordinary Differential Equations (6,0 ECTS)

Numerical Methods for Partial Differential Equations

Numerical Methods for Partial Differential Equations (7,0 ECTS)

Diplomarbeit

Siehe Abschnitt 9.

Kurzbeschreibung der Module (Short description of modules)

Dieser Abschnitt charakterisiert die Module des Masterstudiums *Interdisciplinary Mathematics* in Kürze. Eine ausführliche Beschreibung ist in Anhang A zu finden.

This section gives a short description of the modules of the master study *Interdisciplinary Mathematics*. A long description of the modules is given in Appendix A.

CFD-codes and turbulent flows (6,0 ECTS) Calculating turbulent flows with CFD-codes. Hydrodynamic stability and transition to turbulence.

Computational fluid dynamics (5,0 ECTS) Numerical methods in fluid dynamics.

Computer programming and parallel computing (8,0 ECTS) Basics of scientific and parallel programming in mathematics.

Continuum and kinetic modeling with PDEs (6,0 ECTS) Modeling with PDEs.

Continuum models in semiconductor theory (7,0 ECTS) Introduction to the operation of semiconductor devices (physical concepts, simulation); modelling of MEMS & NEMS: interaction with fluids, simulation.

German (3,0 ECTS) German language on level A1.

High Performance Computing (6,0 ECTS) Introduction to programming with Python as well as with high-performance parallel computers.

Iterative solution of large systems (6,0 ECTS) Presentation and analysis of the most important iterative schemes for large linear systems of equations (e.g. CG, GMRES, multigrid and domain decomposition methods).

Multi-Physics (6,0 ECTS) Finite element methods for multi-physics. Applied Fluid Mechanics Laboratory.

Numerical Methods for Ordinary Differential Equations (6,0 ECTS) Knowledge of standard discretization methods for the approximation of solutions of ordinary differential equations.

Numerical Methods for Partial Differential Equations (7,0 ECTS) Knowledge of numerical standard models for partial differential equations. Finite element methods. Discontinuous Galerkin methods. Instationary PDEs

Numerical optimisation (6,0 ECTS) Unconstrained optimization: gradient methods, classical Newton method, quasi-Newton method. Constrained optimization: trust region methods, linear programming, (sequential) quadratic programming

Numerical simulation and scientific computing (6,0 ECTS) Numerical simulation and scientific computing.

Stationary processes and time series analysis (6,0 ECTS) Multivariate (weakly) stationary processes in discrete time.

Stochastic analysis (7,0 ECTS) Introduction to stochastic analysis, including multidimensional normal distributions, Brownian motion, filtration.

6. Lehrveranstaltungen (Courses)

Die Stoffgebiete der Module werden durch Lehrveranstaltungen vermittelt. Die Lehrveranstaltungen der einzelnen Module sind in Anhang A in den jeweiligen Modulbeschreibungen spezifiziert. Lehrveranstaltungen werden durch Prüfungen im Sinne des UG beurteilt. Die Arten der Lehrveranstaltungsbeurteilungen sind in der Prüfungsordnung (Abschnitt 7) festgelegt.

Betreffend die Möglichkeiten der Studienkommission, Module um Lehrveranstaltungen für ein Semester zu erweitern, und des Studienrechtlichen Organs, Lehrveranstaltungen individuell für einzelne Studierende Wahlmodulen zuzuordnen, wird auf § 27 des Studienrechtlichen Teils der Satzung der TU Wien verwiesen.

7. Prüfungsordnung (Examination regulations)

Der positive Abschluss des Masterstudiums erfordert:

1. die positive Absolvierung der im Studienplan vorgeschriebenen Module, wobei ein Modul als positiv absolviert gilt, wenn die ihm gemäß Modulbeschreibung zuzurechnenden Lehrveranstaltungen positiv absolviert wurden,

2. die Abfassung einer positiv beurteilten Diplomarbeit und

3. die positive Absolvierung der kommissionellen Abschlussprüfung. Diese erfolgt an der TU Wien mündlich vor einem Prüfungssenat gemäß § 12 und § 19 der *Studienrechtlichen Bestimmungen der Satzung der Technischen Universität Wien* und dient der Präsentation und Verteidigung der Diplomarbeit und dem Nachweis der Beherrschung des wissenschaftlichen Umfeldes. Dabei ist vor allem auf Verständnis und Überblickswissen Bedacht zu nehmen. Die Anmeldevoraussetzungen zur kommissionellen Abschlussprüfung gemäß § 18 (1) der *Studienrechtlichen Bestimmungen der Satzung der Technischen Universität Wien* sind erfüllt, wenn die Punkte 1 und 2 erbracht sind.

Die Studierenden erhalten zum Abschluss jedes Studiensemesters an der TU Wien eine Bestätigung über alle bis zu diesem Zeitpunkt an der TU Wien im Masterstudium „Interdisciplinary Mathematics“ abgeschlossenen Module. Diese Bestätigung beinhaltet

(a) jedenfalls alle Prüfungsfächer und die im Rahmen der Prüfungsfächer absolvierten Module mit ihrem jeweiligen Umfang in ECTS-Punkten und ihren Noten,

(b) ab dem Ende des 3. Semester zusätzlich den gewählten Schwerpunkt „Computational Fluid Dynamics“ sowie

(c) am Ende des 4. Semester außerdem noch
   - das Thema der Diplomarbeit und
   - die Note des Prüfungsfaches Diplomarbeit.

Die Note des Prüfungsfaches „Diplomarbeit“ ergibt sich aus der Note der Diplomarbeit. Die Note jedes anderen Prüfungsfaches ergibt sich durch Mittelung der Noten jener Lehrveranstaltungen, die dem Prüfungsfach über die darin enthaltenen Module zuzuordnen sind, wobei die Noten mit dem ECTS-Umfang der Lehrveranstaltungen gewichtet werden. Bei einem Nachkommateil kleiner gleich 0,5 wird abgerundet, andernfalls wird aufgerundet. Die Gesamtnote ergibt sich analog den Prüfungsfachnoten durch gewichtete Mittelung der Noten aller dem Studium zuzuordnenden Lehrveranstaltungen sowie der Noten der Diplomarbeit und der kommissionellen Abschlussprüfung.

Lehrveranstaltungen des Typs VO (Vorlesung) werden aufgrund einer abschließenden mündlichen und/oder schriftlichen Prüfung beurteilt. Alle anderen Lehrveranstaltungen besitzen immanenten Prüfungscharakter, d.h., die Beurteilung erfolgt laufend durch eine begleitende Erfolgskontrolle sowie optional durch eine zusätzliche abschließende Teilprüfung.

Zusätzlich können zur Erhöhung der Studierbarkeit Gesamtprüfungen zu Lehrveranstaltungen mit immanentem Prüfungscharakter angeboten werden, wobei diese wie ein Prüfungstermin für eine Vorlesung abgehalten werden müssen und § 16 (6) des *Studienrechtlichen Teils der Satzung der Technischen Universität Wien* hier nicht anwendbar ist.

Der positive Erfolg von Prüfungen und wissenschaftlichen sowie künstlerischen Arbeiten ist mit „sehr gut“ (1), „gut“ (2), „befriedigend“ (3) oder „genügend“ (4), der negative Erfolg ist mit „nicht genügend“ (5) zu beurteilen.

8. Studierbarkeit und Mobilität (Academic feasibility and mobility)

Studierende im Masterstudium „Interdisciplinary Mathematics“ sollen ihr Studium mit angemessenem Aufwand in der dafür vorgesehenen Zeit abschließen können.

Die notwendige Bereitschaft zur Mobilität der Studierenden ist ein wesentliches Element des Masterstudium „Interdisciplinary Mathematics“. Das erste Semester absolvieren die Studierenden an der Università degli Studi dell’Aquila (im Wintersemester), das zweite Semester an der Technischen Universität Wien (im Sommersemester) und das dritte Semester (im Wintersemester) wahlweise an der Technischen Universität Wien, der Università degli Studi dell’Aquila (L’Aquila) oder der Universitat Autònoma de Barcelona. Das vierte Semester (im Sommersemester) ist für die Anfertigung der Masterarbeit vorgesehen und kann an einer der drei Universitäten absolviert werden. In diesem fest definierten Studienablauf ist es die Pflicht jeder/jedes Studierenden, an allen zwei (bzw. drei) Universitäten in der vorgeschriebenen Reihenfolge zu studieren. Jede Universität steuert somit einen bestimmten Teil zum Studium bei.

Die Anerkennung von im Ausland absolvierten Studienleistungen erfolgt durch das zuständige studienrechtliche Organ. Zur Erleichterung der Mobilität stehen die in § 27 Abs. 1 bis 3 der *Studienrechtlichen Bestimmungen der Satzung der Technischen Universität Wien* angeführten Möglichkeiten zur Verfügung. Diese Bestimmungen können in

Einzelfällen auch zur Verbesserung der Studierbarkeit eingesetzt werden.

Eine Lehrveranstaltung aus den Pflichtmodulen und gewählten Wahlmodulen ist nur dann zu absolvieren, wenn nicht schon eine äquivalente Lehrveranstaltung in dem der Zulassung zum Masterstudium zu Grunde liegenden Studium absolviert wurde; ansonsten sind an ihrer Stelle eine oder mehrere beliebige Lehrveranstaltungen aus den nicht gewählten Modulen des Masterstudiums im selben ECTS-Punkteumfang zu absolvieren, die dann bezüglich Prüfungsfachzuordnung und Klauseln die Rolle der solcherart ersetzten Lehrveranstaltung einnehmen. Die Äquivalenzfeststellung obliegt dem Studienrechtlichen Organ.

Für die Wahl einer Lehrveranstaltung in die anderen Module gilt in jedem Fall, dass diese nicht nochmals als Lehrveranstaltung für das entsprechende Modul gewählt werden kann, wenn eine dazu äquivalente Lehrveranstaltung zur Erreichung jenes Studienabschlusses notwendig war, auf dem das Masterstudium aufbaut. An ihrer Stelle sind beliebige noch nicht gewählte Lehrveranstaltungen aus den nicht gewählten Modulen des Masterstudiums im selben ECTS-Punkteumfang zu absolvieren, die dann bezüglich Prüfungsfachzuordnung und Klauseln die Rolle der solcherart ersetzten Lehrveranstaltung einnehmen. Die Äquivalenzfeststellung obliegt dem Studienrechtlichen Organ.

Lehrveranstaltungen, die bereits vor Beginn des Masterstudiums absolviert wurden, aber nicht zur Erreichung jenes Studienabschlusses notwendig waren, auf dem das Masterstudium aufbaut, sind gemäß § 78 UG für Lehrveranstaltungen des Masterstudiums anzuerkennen.

9. Diplomarbeit (Diploma thesis)

Die Diplomarbeit ist eine wissenschaftliche Arbeit, die dem Nachweis der Befähigung dient, ein wissenschaftliches Thema selbstständig inhaltlich und methodisch vertretbar zu bearbeiten. Das Thema der Diplomarbeit ist von der oder dem Studierenden frei wählbar und muss im Einklang mit dem Qualifikationsprofil stehen. Die kommissionelle Abschlussprüfung deckt mindestens zwei mathematische oder fachverwandte Gebiete (z.B. aus der Informatik oder dem Maschinenbau) ab.

Das Prüfungsfach *Diplomarbeit* umfasst 30 ECTS-Punkte und besteht aus der wissenschaftlichen Arbeit (Diplomarbeit), die mit 27 ECTS-Punkten bewertet wird, sowie aus der kommissionellen Abschlussprüfung im Ausmaß von 3 ECTS-Punkten.

10. Akademischer Grad (Academic degree)

Den Absolvent_innen des Masterstudiums „Interdisciplinary Mathematics“ wird der akademische Grad „Master of Science“ – abgekürzt „MSc“ – verliehen, und zwar als „Joint Degree“ zwischen Università degli Studi dell’Aquila (L’Aquila), Universitat Autònoma de Barcelona und der Technischen Universität Wien. Die Aushändigung der Diplomurkunde erfolgt durch die Universität L’Aquila.

The graduates of the master program „Interdisciplinary Mathematics“ will be awarded the academic degree „Master of Science“ – abbreviated „MSc“, as a „Joint Degree“ between Università degli Studi dell'Aquila (L'Aquila), Universitat Autònoma de Barcelona and Technische Universität Wien. The diploma is awarded by the University of L'Aquila.

11. Qualitätsmanagement (Quality management)

Das Qualitätsmanagement des Masterstudiums *Interdisciplinary Mathematics* gewährleistet, dass das Studium in Bezug auf die studienbezogenen Qualitätsziele der TU Wien konsistent konzipiert ist und effizient und effektiv abgewickelt sowie regelmäßig überprüft wird. Das Qualitätsmanagement des Studiums erfolgt entsprechend dem Plan-Do-Check-Act Modell nach standardisierten Prozessen und ist zielgruppenorientiert gestaltet. Die Zielgruppen des Qualitätsmanagements sind universitätsintern die Studierenden und die Lehrenden sowie extern die Gesellschaft, die Wirtschaft und die Verwaltung, einschließlich des Arbeitsmarktes für die Studienabgänger_innen.

In Anbetracht der definierten Zielgruppen werden sechs Ziele für die Qualität der Studien an der Technischen Universität Wien festgelegt: (1) In Hinblick auf die Qualität und Aktualität des Studienplans ist die Relevanz des Qualifikationsprofils für die Gesellschaft und den Arbeitsmarkt gewährleistet. In Hinblick auf die Qualität der inhaltlichen Umsetzung des Studienplans sind (2) die Lernergebnisse in den Modulen des Studienplans geeignet gestaltet um das Qualifikationsprofil umzusetzen, (3) die Lernaktivitäten und -methoden geeignet gewählt, um die Lernergebnisse zu erreichen, und (4) die Leistungsnachweise geeignet, um die Erreichung der Lernergebnisse zu überprüfen. (5) In Hinblick auf die Studierbarkeit der Studienpläne sind die Rahmenbedingungen gegeben, um diese zu gewährleisten. (6) In Hinblick auf die Lehrbarkeit verfügt das Lehrpersonal über fachliche und zeitliche Ressourcen um qualitätsvolle Lehre zu gewährleisten.

Um die Qualität der Studien zu gewährleisten, werden der Fortschritt bei Planung, Entwicklung und Sicherung aller sechs Qualitätsziele getrennt erhoben und publiziert. Die Qualitätssicherung überprüft die Erreichung der sechs Qualitätsziele. Zur Messung des ersten und zweiten Qualitätszieles wird von der Studienkommission zumindest einmal pro Funktionsperiode eine Überprüfung des Qualifikationsprofils und der Modulbeschreibungen vorgenommen. Zur Überprüfung der Qualitätsziele zwei bis fünf liefert die laufende Bewertung durch Studierende, ebenso wie individuelle Rückmeldungen zum Studienbetrieb an das Studienrechtliche Organ, laufend ein Gesamtbild über die Abwicklung des Studienplans. Die laufende Überprüfung dient auch der Identifikation kritischer Lehrveranstaltungen, für welche in Abstimmung zwischen studienrechtlichem Organ, Studienkommission und Lehrveranstaltungsleiter_innen geeignete Anpassungsmaßnahmen abgeleitet und umgesetzt werden. Das sechste Qualitätsziel wird durch qualitätssichernde Instrumente im Personalbereich abgedeckt. Zusätzlich zur internen Qualitätssicherung wird alle sieben Jahre eine externe Evaluierung der Studien vorgenommen.

12. Inkrafttreten (Effective date)

Dieser Studienplan tritt mit 1. Oktober 2021 in Kraft.

13. Übergangsbestimmungen (Transitional regulations)

Die Übergangsbestimmungen werden gesondert im Mitteilungsblatt verlautbart und liegen im Dekanat der Fakultät für Mathematik und Geoinformation auf.

A. Modulbeschreibungen (Description of modules)

Die den Modulen zugeordneten Lehrveranstaltungen werden in folgender Form angeführt:

9,9/9,9 XX Titel der Lehrveranstaltung

Dabei bezeichnet die erste Zahl den Umfang der Lehrveranstaltung in ECTS-Punkten und die zweite ihren Umfang in Semesterstunden. ECTS-Punkte sind ein Maß für den Arbeitsaufwand der Studierenden, wobei ein Studienjahr 60 ECTS-Punkte umfasst und ein ECTS-Punkt 25 Stunden zu je 60 Minuten entspricht. Semesterstunden sind ein Maß für die Beauftragung der Lehrenden. Bei Vorlesungen entspricht eine Semesterstunde einer Vorlesungseinheit von 45 Minuten je Semesterwoche. Der Typ der Lehrveranstaltung (XX) ist in Anhang B im Detail erläutert.

CFD-codes and turbulent flows

Standard work effort: 6,0 ECTS

Contents: Application of commercial and open source CFD programs: calculation of (turbulent) flows, different turbulence models, verification by data from the literature. Hydrodynamic stability analysis and transition from laminar flow to turbulence.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming; moreover sound knowledge of ordinary and partial differential equations and Functional analysis 1. Moreover, a basic knowledge of physical principles and, in particular, mechanics, is required.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:

3,0/2,0 UE Calculating turbulent flows with CFD-codes
3,0/2,0 VO Hydrodynamic stability and transition to turbulence

Computational fluid dynamics

Standard work effort: 5,0 ECTS

Contents: Methods for convection-diffusion equations, projection methods for incompressible and compressible Navier-Stokes equations, treatment of complex geometries, turbulence modeling.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming; moreover sound knowledge of ordinary and partial differential equations and Functional analysis 1. Moreover, a basic knowledge of physical principles and, in particular, mechanics, is required.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:
3,0/2,0 VO Numerical methods in fluid dynamics
2,0/2,0 UE Numerical methods in fluid dynamics

Computer programming and parallel computing

Standard work effort: 8,0 ECTS

Contents: *Scientific Programming for Interdisciplinary Mathematics:* Object-oriented design and programming: variables and standard data types, pointers, functions and recursion, call by value vs. call by reference, loops, objects and classes (resp. structures), inheritance, templates. Programming with MATLAB: MATLAB syntax (command- and object-oriented), graphical representations, problems in linear algebra, optimization and statistics, solution of differential equations by functions in various toolboxes.

Parallel Programming for Interdisciplinary Mathematics: Introduction to parallel computing.

Expected Prerequisites:

Professional and methodological competencies: Material of the courses that is common to all mathematics bachelor studies at Technische Universität Wien (in particular solid knowledge of Analysis 1–3, Numerical mathematics, basic programming skills, and some knowledge of ordinary differential equations).

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover usage of PCs, internet, standard software (at least word processing, handling of typical user interfaces), simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in (programming) examples. Oral and/or written exams with computational/programming examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:

5,0/4,0 VU Scientific Programming for Interdisciplinary Mathematics
3,0/2,0 VU Parallel Programming for Interdisciplinary Mathematics

Continuum and kinetic modeling with PDEs

Standard work effort: 6,0 ECTS

Learning Outcomes:

Professional and methodological competencies: Knowledge of the below mentioned contents as well as methods of proof and computation, which appear in the modules listed subsequently.

Cognitive and practical competencies: Further development and deepening of the skills acquired in the previous modules, such that the student could – potentially – write a diploma theses in this field.

Social competencies and self-competencies: Development of individual ideas to solve problems. Presentation at the blackboard. Development of solutions in groups.

Contents: Treatment of several selected application problems from natural sciences (e.g. from fluid dynamics) and technical sciences by means of (mostly nonlinear) partial differential equations. This includes modeling aspects, the analysis and numerics of the involved PDEs, as well as the interpretation of the solution for an application problem.

Expected Prerequisites:

Professional and methodological competencies: Professional and methodical competences: It is expected that students are familiar with the contents of the courses Analysis 1–3, Linear algebra 1,2, (linear) Partial differential equations as well as Measure theory. Moreover, a basic knowledge of physical principles and, in particular, mechanics, is required.

Cognitive and practical competencies: The contents and methodology of the listed courses should be familiar and mastered to such a degree, that the student can make theoretical considerations and can solve concrete problems independently.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues. Contact with the application and practitioner's perspective of mathematical problems.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples. Assessment of performance via regular homework, performance at the blackboard and/or tests.

Lectures of the module:
4,5/3,0 VO Modeling with PDEs
1,5/1,0 UE Modeling with PDEs

Continuum models in semiconductor theory

Standard work effort: 7,0 ECTS

Learning Outcomes:

Professional and methodological competencies: Knowledge of the below mentioned contents as well as methods of proof and computation, which appear in the modules listed subsequently.

Cognitive and practical competencies: Further development and deepening of the skills acquired in the previous modules, such that the student could – potentially – write a diploma theses in this field.

Social competencies and self-competencies: Development of individual ideas to solve problems. Presentation at the blackboard. Development of solutions in groups.

Contents: Introduction to the operation of semiconductor devices (physical concepts, simulation); modelling of MEMS & NEMS: interaction with fluids, simulation

Expected Prerequisites: Basic knowledge of physics. Analysis 1 – 3, differential equations.

Compulsory Prerequisites: None.

Lectures of the module:
4,0/3,0 VU Introduction to semiconductor physics and devices
3,0/2,0 VO Theory, modeling and simulation of MEMS & NEMS

German

Standard work effort: 3,0 ECTS

Learning Outcomes: Students will reach a basic level of both written and spoken German (A1 level according to CEFR).

Contents: German (A1 level): Greetings and introductions. Expressing likes and dislikes. Talking about daily activities. Understanding and using everyday expressions as well as basic phrases related to daily needs (buying something, asking for directions, ordering a meal). Interacting in a very simple way about known topics (family, nationality, home, studies).

Expected Prerequisites: No previous knowledge in German is expected.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Communicative teaching approach; oral and written assessment of the language com- petence.

Lectures of the module:
3,0/2,0 VU German A1
German courses at the level A1 with the option to earn ECTS credits are offered by:

- TU & Innes Institute Vienna (3 ECTS)
- Sprachenzentrum der Universität Wien (4 ECTS)

Both of these courses are offered by external institutions and hence they are with costs.

High Performance Computing

Standard work effort: 6,0 ECTS

Learning Outcomes: After having completed this module, student are able to solve specific problems by writing programs in Python as well as assess the characteristics of High-Performance Computers and the expected performance of parallel programs and analyze and design algorithms for communication operations.

Contents: Introduction to programming with Python. Overview of current HPC architectures and communication networks, problems, algorithms and solutions (with project/exercises); advanced MPI programming (with project/exercise), tools, performance models, libraries (with project/exercise).

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Algorithms and Data Structures as well as Parallel Computing.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Program and Project submission and presentation, oral and/or written examination.

Lectures of the module:
1,5/1,0 VO Introduction to Python for Interdisciplinary Mathematics
4,5/3,0 VU High Performance Computing

Iterative solution of large systems

Standard work effort: 6,0 ECTS

Learning Outcomes:

Professional and methodological competencies: The students know the below mentioned contents and hence master important algorithms for the numerical treatment of ODEs and PDEs as well as modern applications of (nonlinear) PDEs in natural and technical sciences.

Cognitive and practical competencies: The students have a basic knowledge of the numerical treatment of PDEs including its implementation. They understand the essential properties of the most important numerical method classes as well as some differential equation models.

Social competencies and self-competencies: Development of individual ideas to solve problems. Presentation at the blackboard. Development of solutions in groups.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming; moreover sound knowledge of ordinary and partial differential equations and Functional analysis 1.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular home- work, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:
4,5/3,0 VO Iterative solution of large systems
1,5/1,0 UE Iterative solution of large systems

Multi-Physics

Standard work effort: 6,0 ECTS

Learning Outcomes:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming; moreover sound knowledge of ordinary and partial differential equations and Functional analysis 1. Moreover, a basic knowledge of physical principles and, in particular, mechanics is required.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Contents: Finite-Element method and aspects for computer implementation, computation of mechanical problems, coupled field problems (magnetic, mechanical and acoustic), optimization of modern mechatronic systems. Applied Fluid Mechanics Laboratory: viscosimetry, classical optical measurement methods, visualization of flows (e.g. Schlieren-method, Hele-Shaw cell).

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, as well as with numerical mathematics and programming, FEM, fluid dynamics.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Applied Fluid Mechanics Laboratory: experiments, measurements.

Lectures of the module:
4,0/3,0 VU Finite element methods for multi-physics I
2,5/2,0 LU Applied Fluid Mechanics Laboratory

Numerical Methods for Ordinary Differential Equations

Standard work effort: 6,0 ECTS

Contents: Knowledge of standard discretization methods for the approximation of solutions of ordinary differential equations. Initial and boundary value problems for ordinary differential equations, one-step and multistep method, symplectic integrators, step-size control (adaptivity). Introduction to numerical methods for partial differential equations.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:
4,0/3,0 VO AKNUM Numerical methods for ODEs
2,0/1,5 UE AKNUM Numerical methods for ODEs

Numerical Methods for Partial Differential Equations

Standard work effort: 7,0 ECTS

Contents: Variational formulation of PDEs and function spaces, Finite element convergence theory, Discontinuous Galerkin methods for convection dominated problems, Mixed methods and applications in fluid mechanics, Nonlinear equations and applications in solid mechanics, Vectorial function spaces and applications in electromagnetics, Instationary PDEs and time-stepping methods, Analysis of iterative solvers and preconditioners, A-posteriori error estimates and adaptivity

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming as well as Functional analysis 1.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:
4,0/3,0 VO AKNUM Numerical methods for PDEs
3,0/2,0 UE AKNUM Numerical methods for PDEs

Numerical optimisation

Standard work effort: 6,0 ECTS

Contents: Unconstrained optimization: gradient methods, classical Newton method, quasi-Newton method (e.g. BFGS method); Constrained optimisation: trust region methods, linear programming (simplex method, interior point method), quadratic programming (inner point method, active sets method), sequential quadratic programming.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming; moreover sound knowledge of ordinary and partial differential equations and Functional analysis 1.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:
4,5/3,0 VO AKNUM, AKOR Numerical optimisation
1,5/1,0 UE AKNUM, AKOR Numerical optimisation

Numerical simulation and scientific computing

Standard work effort: 6,0 ECTS

Contents: Essential features of scientific computing: numerical methods for differential equations, selected programming languages, computer architectures, performance issues.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1-3, Linear algebra 1,2, numerical mathematics and programming.

Cognitive and practical competencies: The contents and methodology of the above listed courses should be familiar and mastered; moreover simple programming abilities.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in (programming) examples. Oral and/or written exams with computational/programming examples and theoretical questions. Practising of the learned material via the independent solving of practical examples (including programming exercises). Assessment of performance via regular homework, performance at the blackboard and/or programming projects and/or tests.

Lectures of the module:
6,0/3,0 VU Numerical simulation and scientific computing I

Stationary processes and time series analysis

Standard work effort: 6,0 ECTS

Learning Outcomes:

Professional and methodological competencies: Knowledge of the below mentioned contents as well as methods of proof and computation, which appear in the modules listed subsequently.

Cognitive and practical competencies: Further development and deepening of the skills acquired in the previous modules, such that the student could – potentially – write a diploma theses in this field.

Social competencies and self-competencies: Development of individual ideas to solve problems. Presentation at the blackboard. Development of solutions in groups.

Contents: Multivariate (weakly) stationary processes in discrete time, auto-covariance function, spectral representation, spectrum, linear filters, transfer function, AR/ARMA processes, forecasting, Wold representation, estimation.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Linear algebra 1,2, statistics and probability theory.

Cognitive and practical competencies: The contents and methodology of the listed courses should be familiar and mastered to such a degree, that the student can make theoretical considerations and can solve concrete problems independently.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples. Assessment of performance via regular homework, performance at the blackboard and/or tests.

Lectures of the module:
4,5/3,0 VO Stationary processes and time series analysis
1,5/1,0 UE Stationary processes and time series analysis

Stochastic analysis

Standard work effort: 7,0 ECTS

Learning Outcomes:

Professional and methodological competencies: Knowledge of the below mentioned contents as well as methods of proof and computation, which appear in the modules listed subsequently.

Cognitive and practical competencies: Further development and deepening of the skills acquired in the previous modules, such that the student could – potentially – write a diploma theses in this field.

Social competencies and self-competencies: Development of individual ideas to solve problems. Presentation at the blackboard. Development of solutions in groups.

Contents: Definition and properties of multi-dimensional normal distribution, definition and elementary properties of Brownian motion, existence and Hölder continuity of Brownian motion using the Kolmogorov-Chentsov continuity criterion, filtrations, stopping times, progressive measurability, path properties, martingales, uniform integrability, Vitali's convergence theorem, sub- and supermartingales, maximum inequality, Doob's inequality for p-integrable submartingales, Doob's optional sampling theorem with applications, local martingales and examples, integration of predictable step processes, p-variation of functions, quadratic variation and covariation process of continuous local martingales, Kunita-Watanabe inequality, stochastic integration for continuous local martingales and generalization for continuous semimartingales.

Expected Prerequisites:

Professional and methodological competencies: It is expected that students are familiar with the contents of the courses Analysis 1–3, Linear algebra 1,2, (linear) partial differential equations. The courses also require foundations of measure and probability theory, and basics of statistics and stochastic processes.

Cognitive and practical competencies: The contents and methodology of the listed courses should be familiar and mastered to such a degree, that the student can make theoretical considerations and can solve concrete problems independently.

Social competencies and self-competencies: Ability to master the organizational challenges of the theoretical and exercise courses, capability of independent communication with colleagues.

Compulsory Prerequisites: None.

Teaching methods, forms of learning and performance assessment: Lecture on the theoretical foundations and essential tools of the before mentioned chapters as well as illustration of their application in examples. Oral and/or written exams with computational examples and theoretical questions. Practising of the learned material via the independent solving of practical examples. Assessment of performance via regular homework, performance at the blackboard and/or tests.

Lectures of the module:

5,0/3,0 VO Stochastic analysis in financial and actuarial mathematics 1
2,0/1,0 UE Stochastic analysis in financial and actuarial mathematics 1

B. Lehrveranstaltungstypen (Types of courses)

EX: Exkursionen sind Lehrveranstaltungen, die außerhalb des Studienortes stattfinden. Sie dienen der Vertiefung von Lehrinhalten im jeweiligen lokalen Kontext.

LU: Laborübungen sind Lehrveranstaltungen, in denen Studierende in Gruppen unter Anleitung von Betreuer_innen experimentelle Aufgaben lösen, um den Umgang mit Geräten und Materialien sowie die experimentelle Methodik des Faches zu lernen. Die experimentellen Einrichtungen und Arbeitsplätze werden zur Verfügung gestellt.

PR: Projekte sind Lehrveranstaltungen, in denen das Verständnis von Teilgebieten eines Faches durch die Lösung von konkreten experimentellen, numerischen, theoretischen oder künstlerischen Aufgaben vertieft und ergänzt wird. Projekte orientieren sich an den praktischberuflichen oder wissenschaftlichen Zielen des Studiums und ergänzen die Berufsvorbildung bzw. wissenschaftliche Ausbildung.

SE: Seminare sind Lehrveranstaltungen, bei denen sich Studierende mit einem gestellten Thema oder Projekt auseinander setzen und dieses mit wissenschaftlichen Methoden bearbeiten, wobei eine Reflexion über die Problemlösung sowie ein wissenschaftlicher Diskurs gefordert werden.

UE: Übungen sind Lehrveranstaltungen, in denen die Studierenden das Verständnis des Stoffes der zugehörigen Vorlesung durch Anwendung auf konkrete Aufgaben und durch Diskussion vertiefen. Entsprechende Aufgaben sind durch die Studierenden einzeln oder in Gruppenarbeit unter fachlicher Anleitung und Betreuung durch die Lehrenden (Universitätslehrer_innen sowie Tutor_innen) zu lösen. Übungen können auch mit Computerunterstützung durchgeführt werden.

VO: Vorlesungen sind Lehrveranstaltungen, in denen die Inhalte und Methoden eines Faches unter besonderer Berücksichtigung seiner spezifischen Fragestellungen, Begriffsbildungen und Lösungsansätze vorgetragen werden. Bei Vorlesungen herrscht keine Anwesenheitspflicht.

VU: Vorlesungen mit integrierter Übung vereinen die Charakteristika der Lehrveranstaltungstypen VO und UE in einer einzigen Lehrveranstaltung.

C. Prüfungsfächer an der TU Wien mit den zugeordneten Modulen und Lehrveranstaltungen

Prüfungsfach „CFD Codes and Turbulent Flows“

Modul „CFD-codes and turbulent flows“ (6,0 ECTS)

3,0/2,0 UE Calculating turbulent flows with CFD-codes
3,0/2,0 VO Hydrodynamic stability and transition to turbulence

Prüfungsfach „Computational Fluid Dynamics“

Modul „Computational fluid dynamics“ (5,0 ECTS)

3,0/2,0 VO Numerical methods in fluid dynamics
2,0/2,0 UE Numerical methods in fluid dynamics

Prüfungsfach „Computer Programming and Parallel Computing“

Modul „Computer programming and parallel computing“ (8,0 ECTS)

5,0/4,0 VU Scientific Programming for Interdisciplinary Mathematics
3,0/2,0 VU Parallel Programming for Interdisciplinary Mathematics

Prüfungsfach „Continuum and Kinetic Modelling with PDEs“

Modul „Continuum and kinetic modeling with PDEs“ (6,0 ECTS)

4,5/3,0 VO Modeling with PDEs
1,5/1,0 UE Modeling with PDEs

Prüfungsfach „Elective Module A“

Modul „Numerical optimisation“ (6,0 ECTS)

4,5/3,0 VO AKNUM, AKOR Numerical optimisation
1,5/1,0 UE AKNUM, AKOR Numerical optimisation

Modul „Iterative solution of large systems“ (6,0 ECTS)

4,5/3,0 VO Iterative solution of large systems
1,5/1,0 UE Iterative solution of large systems

Modul „Stationary processes and time series analysis“ (6,0 ECTS)

4,5/3,0 VO Stationary processes and time series analysis
1,5/1,0 UE Stationary processes and time series analysis

Prüfungsfach „Elective Module B“

Modul „Numerical simulation and scientific computing“ (6,0 ECTS)

6,0/3,0 VU Numerical simulation and scientific computing I

Modul „Multi-Physics“ (6,0 ECTS)

4,0/3,0 VU Finite element methods for multi-physics I
2,5/2,0 LU Applied Fluid Mechanics Laboratory

Modul „High Performance Computing“ (6,0 ECTS)

1,5/1,0 VO Introduction to Python for Interdisciplinary Mathematics
4,5/3,0 VU High Performance Computing

Prüfungsfach „Elective Module C“

Modul „Continuum models in semiconductor theory“ (7,0 ECTS)

4,0/3,0 VU Introduction to semiconductor physics and devices
3,0/2,0 VO Theory, modeling and simulation of MEMS & NEMS

Modul „Stochastic analysis“ (7,0 ECTS)

5,0/3,0 VO Stochastic analysis in financial and actuarial mathematics 1
2,0/1,0 UE Stochastic analysis in financial and actuarial mathematics 1

Prüfungsfach „German“

Modul „German“ (3,0 ECTS)

3,0/2,0 VU German A1

Prüfungsfach „Numerical Methods for Ordinary Differential Equations“

Modul „Numerical Methods for Ordinary Differential Equations“ (6,0 ECTS)

4,0/3,0 VO AKNUM Numerical methods for ODEs
2,0/1,5 UE AKNUM Numerical methods for ODEs

Prüfungsfach „Numerical Methods for Partial Differential Equations“

Modul „Numerical Methods for Partial Differential Equations“ (7,0 ECTS)

4,0/3,0 VO AKNUM Numerical methods for PDEs
3,0/2,0 UE AKNUM Numerical methods for PDEs

Prüfungsfach „Diplomarbeit“

3,0 ECTS	Kommissionelle Abschlussprüfung
27,0 ECTS	Diplomarbeit