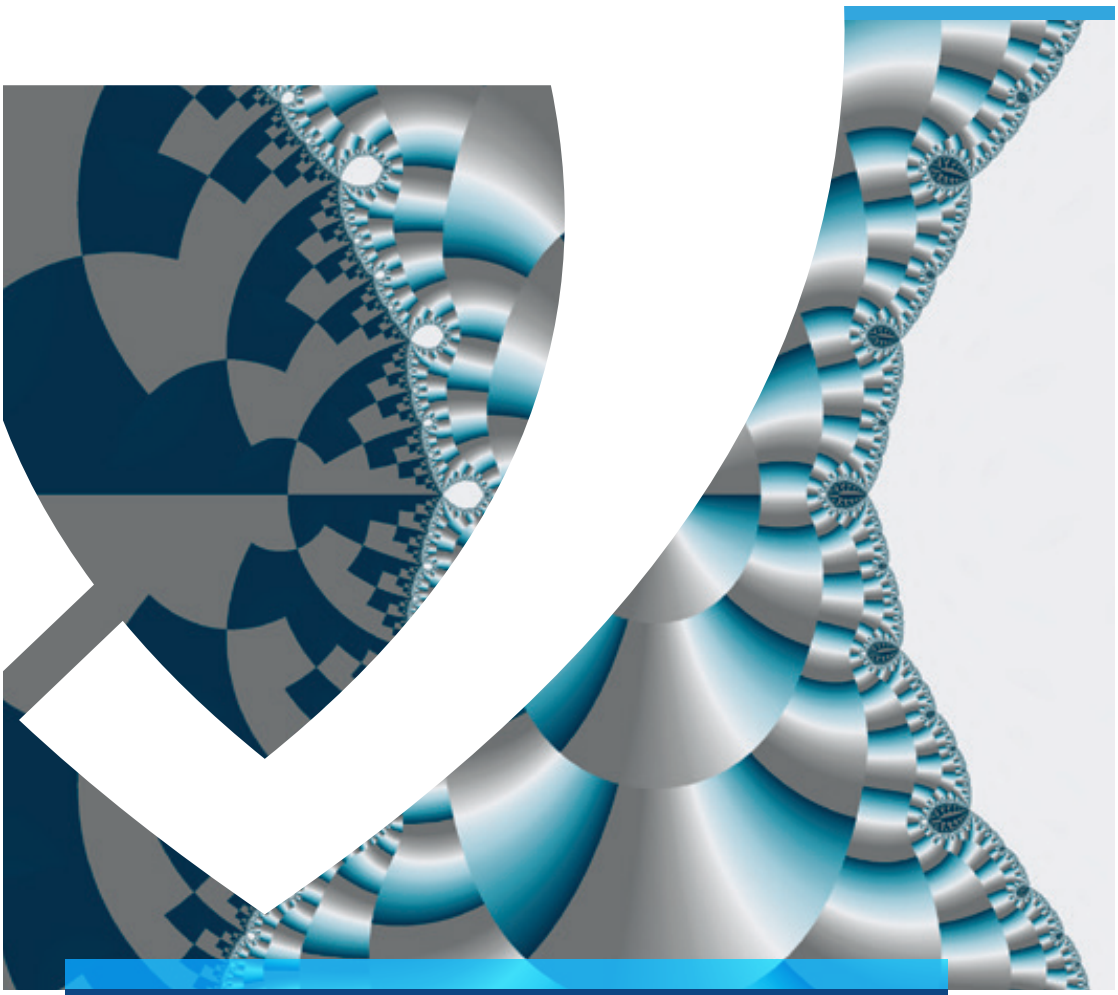
JACOBS UNIVERSITY



Study Program Handbook

Mathematics

Bachelor of Science

Subject-specific Examination Regulations for Mathematics (Fachspezifische Prüfungsordnung)

The subject-specific examination regulations for Mathematics are defined by this program handbook and are valid only in combination with the General Examination Regulations for Undergraduate degree programs (General Examination Regulations = Rahmenprüfungsordnung). This handbook also contains the program-specific Mandatory Module and Examination Plans (Appendix 1a / 1b).

Upon graduation students in this program will receive a Bachelor of Science (BSc) degree with a scope of 180 ECTS (for specifics see chapter 3 of this handbook).

Version	Valid as of	Decision	Details
Fall 2016 - V1	01.09.16	AB August 2016	Master Version
Fall 2016 - V2	01.09.17	AB August 2017	2.2 revised, 2.5 added
Fall 2016 - V3	01.09.18	Academic Senate August 29, 2018	Figure 3 updated

Contents

1 The Mathematics Study Program

1.1 Concept

Mathematics is the most fundamental of the sciences ranging from algebra, analysis, geometry, or topology, to applications of immediate practical importance as for example in modeling fluids using partial differential equations. Mathematics often finds intriguing practical applications in surprising areas: number theory is used in cryptography, dynamical systems and wavelets are successfully at work in engineering, and mathematical game theory has won a Nobel prize in economics. The program also includes elements of applied and computational mathematics. Math students at Jacobs University participate in research groups together with graduate students and faculty, and many have even written research articles.
One key element in our education is that we do not just teach courses to students, but accompany them as individuals throughout their education and help them achieve (or even identify) their personal goals.

1.2 Specific Advantages of the Mathematics Program at Jacobs University

- We teach pure mathematics in modern high level applied contexts.
  Examples: Clean discussion of Linear Algebra embedded into ubiquitous linearization techniques in applications; integral transforms and communications engineering; probability theory and finance; Hilbert space methods and finite elements in computational engineering.
- Top down trumps bottom up!
  Although much of the historical development of mathematics was driven by the desire to build theories bottom up from first principles, this is not a useful didactical concept, not does it reflect the way most research mathematicians work.
- Learn by immersion:
  It is important to learn by discussing mathematics on a formalized regular basis with an active mathematician. This is very analogous to study at a music conservatory. Lectures augment this, not vice versa.
- Learn to interact:
  Discuss with mathematicians and those who apply mathematics alike. Appreciate the complexity of mathematics in the real world, and understand that math is everywhere!
- Small classes:
  Each year, about 20 students will be studying mathematics at Jacobs University. This allows for and one-on-one interaction with faculty, focused study, early research, and a holistic development of mathematical and personal skills.
- Interdisciplinary spirit:
  At Jacobs, there is a lot of mathematics and mathematical modeling across campus. Links are close and personal between faculty, students, and research staff in different fields that work together on common goals.
- We care about each and everyone:
  Students at Jacobs are are known personally to faculty. Individuals can and will get help to develop special interests, but also in time of special needs.

1.3 Program-Specific Qualification Aims

- Graduates who think clearly, formulate cleanly, and present well.
- Graduates who are confident in aquiring, understanding, und organizing information.
- Generic problem solving skills, including a sense of figuring out what is already known, what is not known, and what is required to obtain a solution.
- Broad background in the core fields of pure and applied mathematics (Analysis, Linear Algebra, Numerical Analysis, Probability, Topology, Geometry) at a level allowing easy transition into top graduate schools worldwide.
- Practical skills in programming and the use of standard mathematical software.
- A sense for the use of Mathematics in one or more fields of application.

1.4 The Jacobs University Employability and Personal Development Concept

Jacobs University's educational concept aims at fostering employability which refers to skills, capacities, and competencies which transcend disciplinary knowledge and allow graduates to quickly adapt to professional contexts. Jacobs University defines employability as encompassing not just technical skills and understanding but also personal attributes and qualities enabling students to become responsible members of their professional and academic fields as well as of the societies they live in.

Graduates of JU will be equipped with the ability to find employment and to pursue a successful professional career, which means that

- graduates possess the ability to acquire knowledge rapidly, to assess information and to evaluate new concepts critically;

- graduates have communicative competences which allow them to present themselves and their ideas and to negotiate successfully;

- graduates are familiar with business-related processes and management skills and are able to manage projects efficiently and independently.

Graduates of JU will also be equipped with a foundation to become globally responsible citizens, which includes the following attributes and qualities:

- graduates have gained intercultural competence; they are aware of intercultural differences and possess skills to deal with intercultural challenges; they are familiar with the concept of tolerance;

- graduates can apply problem-solving skills in negotiating and mediating between different points of view;

- graduates can rely on basic civic knowledge and have an understanding for ethical reasoning; students are familiar with the requirements for taking on responsibility.

1.5 Career Options

There are few undergraduate degrees which rival mathematics in the diversity of rewarding job options, which include the following.

- Insurance companies hire large numbers of mathematicians on actuarial and other analyst positions.
- Quantitative Finance and Financial Engineering is another big pool of opportunities which involves fairly deep mathematical concepts.
- Operations Researchers help organizations, businesses, and government find efficient solutions to organizational and strategic planning questions, including scheduling and distribution problems, resource allocation, facilities design, and forecasting.
- Mathematicians are frequently employed in Information Technology positions. In fact, a recent survey from the UK shows that while a substantial number of mathematicians work in IT, few computer scientists compete with mathematicians in any of the other fields of employment. In particular, mathematical knowledge is required for work in information security and cryptography.
- Statisticians are employed by large organizations and work in research and development divisions from academica to industry to analyze data from surveys and experiments.
- Educationist a wide field of employment ranging from secondary school teachers to university professors.
- Engineering Mathematics offers job opportunities from aerospace engineering and petroleum engineering to a wide range of other engineering disciplines.
- Last, but not least, a career as a research mathematician at universities or mathematics research institutes.

1.6 More Information and Contact

For more information please contact the study program coordinators:

Dr. Dierk Schleicher
Professor of Mathematics
Email: dierk@jacobs-university.de
Telephone: +49 421 200-3213

Dr. Marcel Oliver
Professor of Mathematics
Email: m.oliver@jacobs-university.de
Telephone: +49 421 200-3212

or visit our program website: http://math.jacobs-university.de/undergraduate/

2 The Curricular Structure

2.1 General

The undergraduate education at Jacobs University equips students with the key qualifications necessary for a successful academic, as well as professional career. By combining disciplinary depth and transdisciplinary breadth, supplemented by skills education and extracurricular elements, students are prepared to be responsible and successful citizens within the societies they work and live in.

The curricular structure provides multiple elements enhancing employability, transdisciplinarity, and internationality. The unique Jacobs Track, offered across all study programs, provides a broad range of tailor-made courses designed to foster career competencies. These include courses which promote communication, technology, business, (German) language, and management skills. The World Track, included in the third year of study, provides extended company internships or study abroad options. Thus students gain training on the job and intercultural experiences. All undergraduate programs at Jacobs University are based on a coherently modularized structure, which provides students with a broad and flexible choice of study plans to meet their major as well as minor study interests.

The policies and procedures regulating undergraduate study programs at Jacobs University in general can be found on the website.

2.2 The Jacobs University 3C-Model

Jacobs University offers study programs according to the regulations of the European Higher Education Area. All study programs are structured along the European Credit Transfer System (ECTS), which facilitates credit transfer between academic institutions. The three-year undergraduate program involves six semesters of study with a total of 180 ECTS credits. The curricular structure follows an innovative and student-centered modularization scheme - the 3C-Model - which groups the disciplinary content of the three study years according to overarching themes:

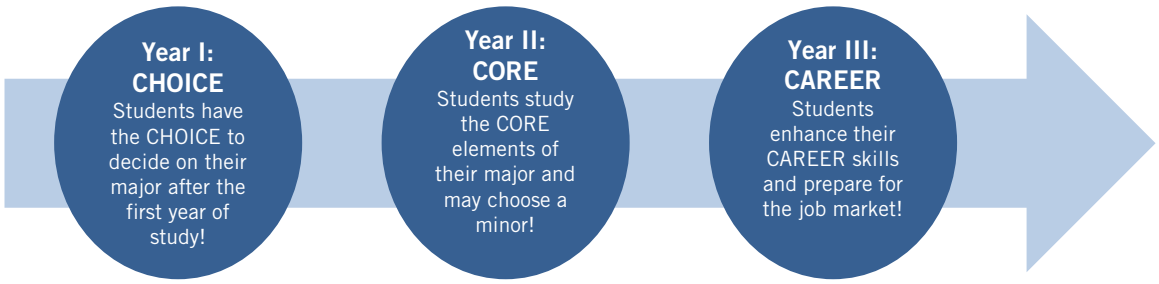


Figure 1: The Jacobs University 3C-Model

2.2.1 YEAR 1 - CHOICE

The first study year is characterized by a broad offer in disciplinary and interdisciplinary education. Students select three CHOICE modules from a variety of study programs. As a unique asset, our curricula allow students to select their study program freely from among the three selected CHOICE modules during their first year of study.

2.2.2 YEAR 2 - CORE

In the second year, students take three in-depth, discipline-specific CORE modules. One CORE module can also be taken from a second, complementary discipline, which allows students to incorporate a minor study track into their undergraduate education. Students will generally qualify for a minor if they have successfully taken at least one CHOICE module and one CORE module in a second field, and this extra qualification will be highlighted in the transcript.

2.2.3 YEAR 3 - CAREER

During their third year, students must decide on their career after graduation. In order to facilitate this decision, the fifth semester introduces two separate tracks. By default students are registered for the World Track.

1. **The World Track**
   In this track there are two mandatory elective options:
   - **Internship**
     The internship program is a core element of Jacobs Universitys employability approach. It includes a mandatory semester-long internship off-campus (minimum 16 weeks in full-time) which provides insight into the labor market as well as practical work experience related to the respective area of study. Successful internships may initiate career opportunities for students. For more information, please contact the Career Services Center (http://www.jacobs- university.de/career-services/contact).
   - **Study Abroad**
     Students can take the opportunity to study abroad at one of our partner universities. Courses recognized as study abroad credits need to be pre-approved according to the Jacobs University study abroad procedures and carry minimum of 20 ECTS credits in total. Several exchange programs allow you to be directly enrolled at prestigious partner institutions worldwide. Jacobs University's participation in Erasmus+, the European Unions exchange program, provides an exchange semester at a number of European universities including Erasmus study abroad funding.
     For more information, please contact the International Office
     (http://intoffice.user.jacobs-university.de/outgoing/).

2. **The Campus Track**
   Alternatively, students may also opt to follow the Campus Track by continuing their undergraduate education at Jacobs, namely by selecting an additional CORE module during their third year and redistributing the remaining courses and modules across the third year. This opportunity can be used by students to more intensively focus on their major or to fulfill the minor requirements for a second field of interest.

In the sixth semester, all students select from a range of specialization courses within their study program and concentrate on their Bachelor thesis in the context of a Project/Thesis Module.

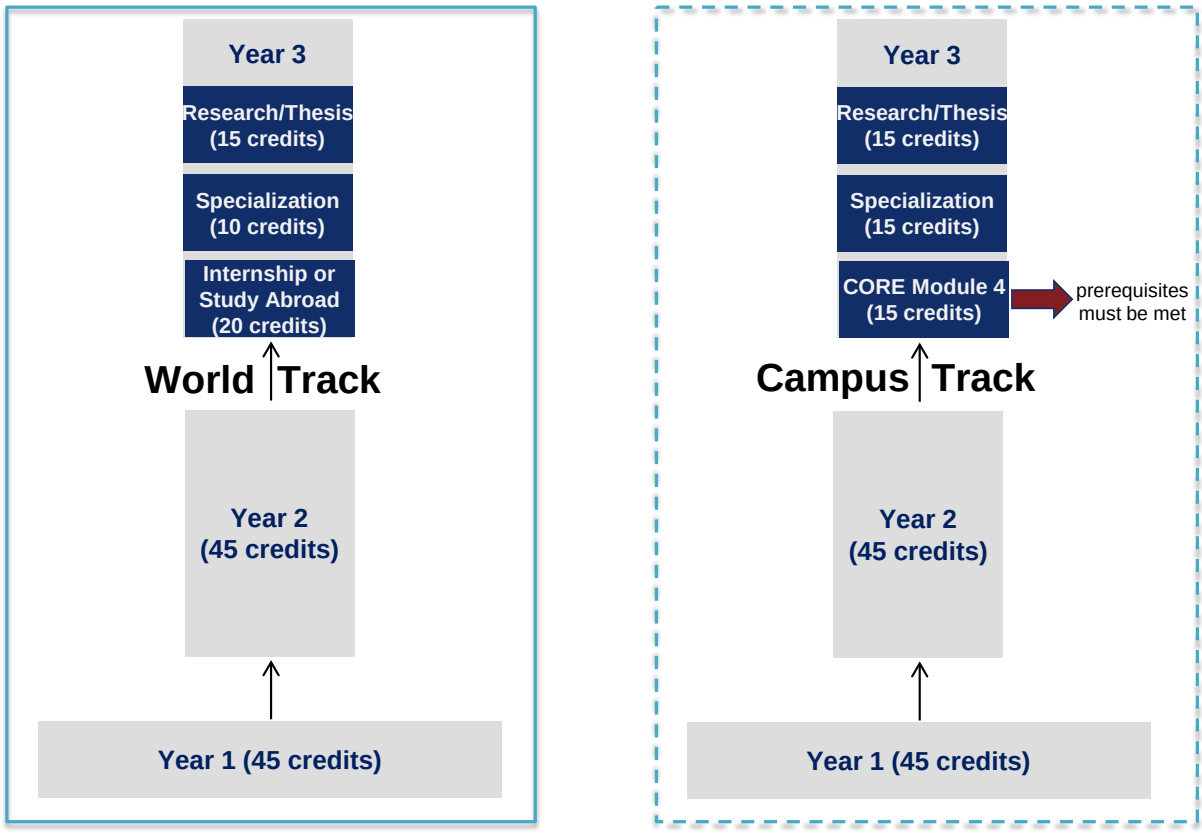


Figure 2: World Track versus Campus Track

Career Skills

Throughout their studies all students attend a mandatory set of career skills courses and events.

The mandatory Career Skills module prepares all undergraduate students at Jacobs University for the transition from student life to working life as well as for their future career. Skills, knowledge and information which are fundamental for participation in an internship or a semester abroad will be conveyed concurrently. Essential components of the module include information sessions, compulsory seminars on various career-relevant topics as well as participation in the annual Jacobs Career Fair.

The successful completion of the Career Skills Module and the encompassed single seminars are graded with Pass/Fail for all students. ECTS credits are not awarded. All undergraduate students will be automatically registered for the Career Skills Module. However, every student has to keep track of his/her individual fulfillment of requirements and has to register on Campusnet for all seminars and sessions during the official registration period at the beginning of each semester. An overview of the sequence in which components should be completed is shown in the table below:

CAREER SKILLS MODULE For Undergraduate Students matriculated Fall 2015 and Fall 2016

SEMESTER	1	2	3	4	5	6
MANDATORY BASICS	CSC-INFO Session: "CSC Services" CA01-990000		CSC-INFO Session: "World Track" CA01-990026			
MANDATORY SEMINARS	Both seminars have to be attended in your first or second semester: CSC-APPLICATION TRAINING CA01-990001 CSC-RESEARCHING & CONTACTING EMPLOYERS CA01-990004					
MANDATORY ELECTIVE SEMINARS (seminar program subject to availability)			Attend 2 out of several career skills seminars and workshops. i.e. ▪ Business Etiquette ▪ Presentation Skills ▪ Communication Skills ▪ Grad School Application Training ▪ Self-Management ▪ Time-Management ▪ Decision Making ▪ Preparing for an Interview ▪ Introduction to Project Management			
OTHER MANDATORY COMPONENTS				CSC-JACOBS CAREER FAIR in February, on campus CA01-990003	INTERNSHIP or STUDY ABROAD or CAMPUS TRACK	INTERNSHIP & STUDY ABROAD EVENT Online CSC-CAREER SURVEY CA01-990002

Figure 3: The Career Skills Module

2.3 The Jacobs Track

The Jacobs Track, another stand-alone feature of Jacobs University, runs parallel to the disciplinary CHOICE, CORE, and CAREER modules across all study years and is an integral part of all study programs. It reflects our commitment to an in-depth methodological education, it fosters our transdisciplinary approach, it enhances employability, and equips students with extra skills desirable in your general field of study. Additionally, it integrates essential language courses.

Mathematics, statistics, and other methods courses are offered to all students within a comprehensive Methods Module. This module provides students with general foundations and transferable techniques which are invaluable to follow the study content not only in the study program itself but also in related fields.

The Skills Module equips students with general academic skills which are indispensable for their chosen area of study. These could be, for example, programming, data handling, presentation skills, and academic writing, scientific and experimental skills.

The transdisciplinary Triangle Module offers courses with a focus on at least one of the areas of business, technology and innovation, and societal context. The offerings comprise essential knowledge of these fields for students from other majors as well as problem-based courses that tackle global challenges from different disciplinary backgrounds. Working together with students from different disciplines and cultural backgrounds in these courses broadens the students horizon by crossing the boundaries of traditional disciplines.

Foreign languages are integrated within the Language Module. Communicative skills and foreign language competence foster students intercultural awareness and enhance their employability in a globalized and interconnected world. Jacobs University supports its students in acquiring and improving these skills by offering a variety of language courses at all proficiency levels. Emphasis is put on fostering German language skills, as they are an important prerequisite for students to learn about, explore, and eventually integrate into their host country. Hence, acquiring 10 ECTS credits in German is a requirement for all students. Students who meet the requirements of the German proficiency level (e.g. native speakers) are required to select courses in any other language program offered.

2.4 Modularization of the Mathematics Program

2.4.1 Content

Year 1
Take the module listed below and select two further CHOICE modules from different study areas.

Fundamental Mathematics (CH07-FundMath)
Fundamental Mathematics is the central first year major-specific module. It complements the first-year Service Mathematics courses in Calculus/Analysis and Linear Algebra with additional in-depth material necessary for any Mathematics student and useful for students of other quantitative majors or those with an independent interest in Mathematics.

Year 2
Take all three modules or replace one with a CORE module from a different study program.

Core Mathematics (CO16-CoreMaths)
The module Core Mathematics contains the courses which are taken by all second year mathematics students. It continues the education in Linear Algebra into the second year of study and develops the theory of integration with elements of Functional Analysis and Fourier Methods. In addition, the module complements the second year education in the Jacobs track by providing additional courses in Numerical Methods and Probability.

Pure Mathematics (CO17-CorePureMath)
The module Core Pure Mathematics contains a set of courses that are central to an education in pure mathematics. It contains an introduction to Geometry and Topology including differential forms, manifolds, and tensors, a first course in Complex Analysis, and a first course in Algebra.

Core Applied Mathematics (CO18-CoreAppMath)
The module Core Applied Mathematics contains a set of core courses which should be taken by all students interested in applications and mathematical modeling. It comprises a first hands-on introduction to theory and applications of dynamical systems, and an introduction to stochastic modeling and mathematical finance. A crucial component of this module will be the use of computer experiments to foster intuitive understanding and develop students' skills in using the computer to bridge between mathematical idea and concrete implementation and application.

Some CORE Modules require students to have taken a specific CHOICE Module. Please see the Module Handbook for details regarding pre-requisites.

Year 3
In the 3rd year students follow the World Track by default:

1. **World Track**
   5th Semester
   - Internship / study abroad

   6th Semester
   - Mathematics Project / Thesis Module

   - Program-specific Specialization Module
     Exemplary course offering:
     - Differential Equations
     - Foundations of Mathematical Physics
     - Number Theory
     - Manifolds and Topology
     - Discrete Structures and Optimization
     - Stochastic Processes and Finance
     - Functional Analysis and Elliptic Operators
     - Numerical Analysis and Scientific Computing
     - Mathematical Modeling with PDEs

2. **Campus Track**
   Students who do not enter the World Track follow the Campus Track.
   5th and 6th Semester

   - Program-specific Project / Thesis Module

   - Program-specific Specialization Module
     (please see World Track for exemplary course offering)

   - Additional CORE Module

2.5 The Bachelor Thesis / Project

This module is a mandatory graduation requirement for all undergraduate students. It consists of two components in the major study program guided by a Jacobs Faculty member:

1. **A Research Project** (5 ECTS)
   and
2. **The Bachelor Thesis** (10 ECTS)

The workload for the project component is about 125 hours and for the thesis component about 250 hours.The title of the thesis will be shown on the transcript.

2.5.1 Aims

Within this module, students apply knowledge they have acquired about their major discipline, skills, and methods to become acquainted with actual research topics, ranging from the identification of suitable (short-term) research projects, preparatory literature searches, the realization of discipline-specific research, and the documentation, discussion, and interpretation of the results. Research results obtained from the Research Project can be embedded in the Bachelor Thesis.

2.5.2 Intended Learning Outcomes

1. Research Project
   This module component consists of a guided research project in the major study program. The well-defined research task must be completed and documented according to the scientific standards in the respective discipline. It involves a high degree of independence, supported by individualized instructor feedback and guidance.
2. Bachelor Thesis
   With their Bachelor Thesis students should demonstrate mastery of the contents and methods of the major specific research field. Furthermore, students should show the ability to analyze and solve a well-defined problem with scientific approaches, a critical reflection of the status quo in scientific literature, and an original development of their own ideas.

Both, the Research Project and the Bachelor Thesis, can also have an inter- or transdisciplinary nature - with the explicit permission of the supervisor.

2.5.3 Supervision

Both module components can be performed with the same Jacobs faculty member, or different ones, the latter in order to allow a broader research experience. Students are required to choose a supervisor, at the latest, by the end of the drop-add period of the semester in which the module component is taken. **The selected supervisor(s) must approve the Project topic and Bachelor Thesis topic before the student starts to work towards the module component.** The respective study program coordinators will assist in the search for prospective supervisor(s).

2.5.4 Registration

World Track students register for both components, at the earliest, in their 6th semester.
Campus Track students register for the Project component in the 5th and for the Bachelor Thesis component, at the earliest, in their 6th semester.

The registrations must be made before the end of the respective drop/add periods.

Later enrolment is possible for those students pursuing a second major or those who graduate late for other reasons. These students perform their (second) thesis earliest in the 7th semester of their studies. They have to contact the Student Records Office for individual registration.

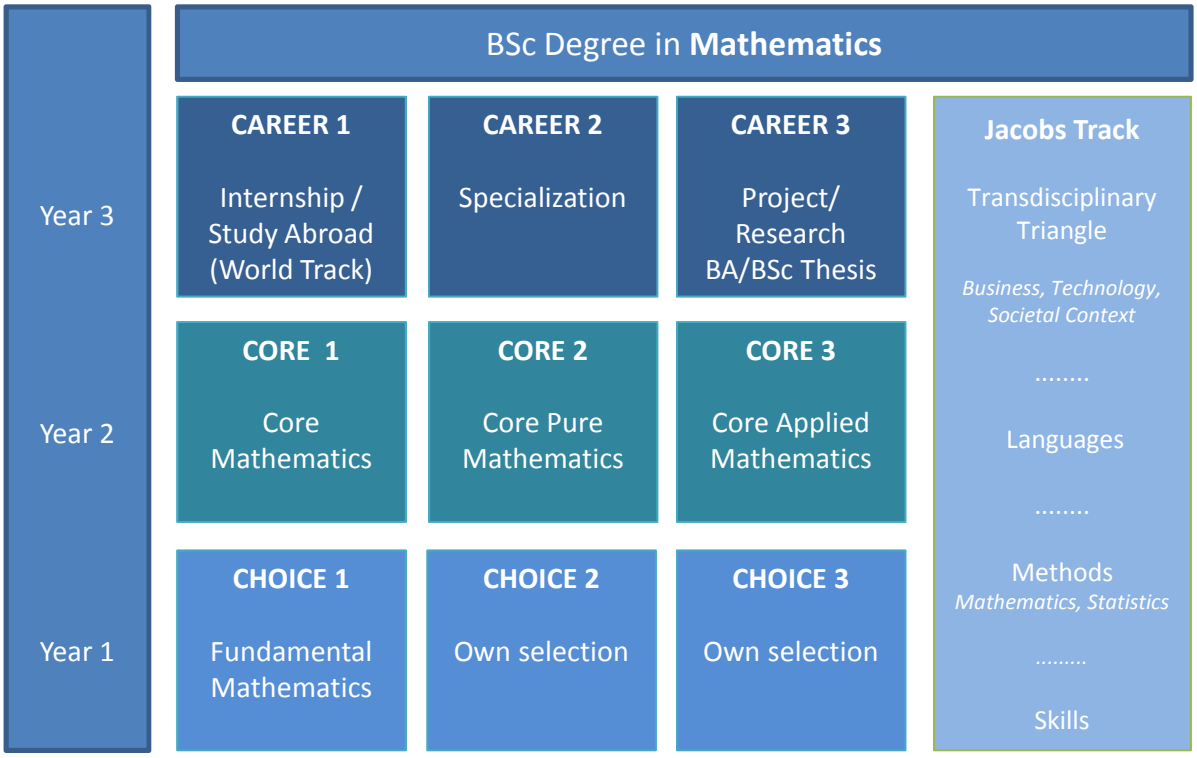
Students are allowed to extend their thesis related work into the intersession or summer break upon approval of the thesis supervisor and Student Records. Students are not allowed to register for different Bachelor Thesis courses in the same semester.

2.5.5 Formal Regulations for the Bachelor Thesis

- Timing
  The Thesis work has to be generated within the semester of registration. The semester period has 14 weeks.
- Extent
  The document must be between 15-25 pages in length, including references, but excluding appendices or supporting information. Deviations in length and format can be determined within individual study programs and should be communicated to all registered students by the study program coordinator.
- Cover page
  The cover page must show the title of the Bachelor Thesis, the university's name, the month and year of submission, the name of the student and the name of the supervisor.
- Statutory Declaration
  Each Bachelor Thesis must include a statutory declaration signed by the student confirming it is their own independent work and that it has not been submitted elsewhere. The respective form can be found on the Student Records Office website.
- Submission
  The Bachelor Thesis must be submitted as a hard copy (pdf-file) to the supervisor and additionally to the Student Records Office via online form on the Student Records Office website.

  Deadline for submission of the Bachelor Thesis is May 15 (unless specified otherwise by the Student Records Office).

2.5.6 Structure



YEAR 1 *Take three CHOICE modules, two free selection*

YEAR 2 *Take three CORE modules, one CORE module can be substituted by a CORE module from a second study program to pursue a minor*

YEAR 3 *Alternatively Campus Track with a 4th CORE module instead of internship/study abroad module*

Figure 4: Mathematics Module Structure

3 Appendix 1a/1b: Mandatory Module and Examination Plans for World Track and Campus Track

Jacobs University Bremen reserves the right to substitute courses by replacements and/or reduce the number of mandatory/mandatory elective courses offered.

4 Appendix 2: Course Data for Program-Specific CHOICE and CORE Courses

All course data stated in the appendix is based on the previous study year and subject to change.

Appendix 1a - Mandatory Module and Examination Plan for World Track

Mathematics – World Track

Matriculation Fall 2016

	Program-Specific Modules	Type	Status[1]	Semester	Credits		Jacobs Track Modules (General Education)	Type	Status[1]	Semester	Credits
Year 1 - CHOICE					**45**						**20**
Take the mandatory CHOICE module listed below, this is a requirement for the Mathematics program.											
CH07-FundMath	**Module: Fundamental Mathematics**		**m**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**10**
CH07-100101	General Mathematics	Lecture	m	1	5		JTME-120203	Elements of Analysis I	Lecture	m	1	2,5
CH07-100111	Mathematical Software Lab	Lab	m	1	2,5		JTME-120204	Elements of Analysis II	Lecture	m	1	2,5
CH07-100212	Analysis II	Lecture	m	2	5		JTME-120112	Foundations of Linear Algebra I	Lecture	m	2	2,5
CH07-100122	Undergraduate Seminar	Lab	m	2	2,5		JTME-120113	Foundations of Linear Algebra II	Lecture	m	2	2,5
	Module: CHOICE (own selection)		**e**	**1/2**	**30**		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
Students take two further CHOICE modules from those offered for all other study programs. [2]							JTSK-320111/350111	Students take either Programming in C I or Programming in Python	Lecture	m	1	2,5
							JT-TA-TriArea	**Module: Triangle Area**		**m**		**2,5**
								Take one course from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	1/2	2,5
							JT-LA-Language	**Module: Language**		**m**		**5**
								Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	1/2	5
Year 2 - CORE					**45**						**20**
Take all three modules or replace one with a CORE module from a different study program. [2]											
CO16-CoreMaths	**Module: Core Mathematics**		**me**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**5**
CO16-100231	Linear Algebra	Lecture	m	3	5		JTME-120201	Elements of Probability	Lecture	m	3	2,5
CO16-100241	Elements of Stochastic Processes	Lecture	m	3	2,5		JTME-120202	Numerical Methods I	Lecture	m	4	2,5
CO16-100232	Introductory Real Analysis	Lecture	m	4	5		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
CO16-100242	Numerical Methods II	Lecture	m	4	2,5		JTSK-320112/350112	Students take either Programming in C II or Advanced Programming in Python	Lecture	m	3/4	2,5
CO17-CorePureMath	**Module: Core Pure Mathematics**		**me**		**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**7,5**
CO17-100251	Introduction to Complex Analysis	Lecture	m	3	5			Take three courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	3/4	7,5
CO17-100261	Calculus on Manifolds	Lecture	m	3	5							
CO17-100252	Introduction to Algebra	Lecture	m	4	5							
CO18-CoreAppMath	**Module: Core Applied Mathematics**		**me**		**15**							
CO18-110221	Stochastic Methods	Lecture	m	3	5		**JT-LA-Language**	**Module: Language**		**m**		**5**
CO18-110222	Stochastic Methods Lab	Lab	m	3	2,5			Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	3/4	5
CO18-110231	Applied Dynamical Systems	Lecture	m	4	5							
CO18-110233	Applied Dynamical Systems Lab	Lab	m	4	2,5							
Year 3 - CAREER					**45**							**5**
CA02 / CA03	**Module: Internship / Study Abroad**		**m**	**5**	**20**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**5**
CA01-CarSkills	**Module: Career Skills**		**m**					Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	6	5
CA12-MATH	**Module: Project/Thesis MATH**		**m**		**15**							
CA12-100303	Project MATH		m	6	5							
CA12-100304	Thesis MATH		m	6	10							
CAS-WT-MATH	**Module: Specialization Area MATH**		**m**		**10**							
	Take four specialization courses (2.5 ECTS each) [2]		me	5/6	10							
Total ECTS												**180**

[1] Status (m = mandatory, e = elective, me = mandatory elective)

[2] For a full listing of all CHOICE / CORE / CAREER / Jacobs Track modules please consult the **CampusNet online catalogue** and / or the module handbook (on our website).

[3] You are required to take six Triangle Area courses in total. Select two from each of the three triangle areas (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT).

Appendix 1b - Mandatory Module and Examination Plan for Campus Track

Mathematics – Campus Track

Matriculation Fall 2016

	Program-Specific Modules	Type	Status[1]	Semester	Credits			Jacobs Track Modules (General Education)	Type	Status[1]	Semester	Credits
Year 1 - CHOICE					**45**							**20**
Take the mandatory CHOICE module listed below, this is a requirement for the Mathematics program.												
CH07-FundMath	**Module: Fundamental Mathematics**		**m**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**10**
CH07-100101	General Mathematics	Lecture	m	1	5		JTME-120203	Elements of Analysis I	Lecture	m	1	2,5
CH07-100111	Mathematical Software Lab	Lab	m	1	2,5		JTME-120204	Elements of Analysis II	Lecture	m	1	2,5
CH07-100212	Analysis II	Lecture	m	2	5		JTME-120112	Foundations of Linear Algebra I	Lecture	m	2	2,5
CH07-100122	Undergraduate Seminar	Lab	m	2	2,5		JTME-120113	Foundations of Linear Algebra II	Lecture	m	2	2,5
	Module: CHOICE (own selection)		**e**	**1/2**	**30**		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
Students take two further CHOICE modules from those offered for all other study programs. [2]							JTSK-320111/350111	Students take either Programming in C I or Programming in Python	Lecture	m	1	2,5
							JT-TA-TriArea	**Module: Triangle Area**		**m**		**2,5**
								Take one course from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	1/2	2,5
							JT-LA-Language	**Module: Language**		**m**		**5**
								Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	1/2	5
Year 2 - CORE					**45**							**20**
Take all three modules or replace one with a CORE module from a different study program. [2]												
CO16-CoreMaths	**Module: Core Mathematics**		**me**		**15**		**JT-ME-MethodsMath**	**Module: Methods / Mathematics**		**m**		**5**
CO16-100231	Linear Algebra	Lecture	m	3	5		JTME-120201	Elements of Probability	Lecture	m	3	2,5
CO16-100241	Elements of Stochastic Processes	Lecture	m	3	2,5		JTME-120202	Numerical Methods I	Lecture	m	4	2,5
CO16-100232	Introductory Real Analysis	Lecture	m	4	5		**JT-SK-Skills**	**Module: Skills**		**m**		**2,5**
CO16-100242	Numerical Methods II	Lecture	m	4	2,5		JTSK-320112/350112	Students take either Programming in C II or Advanced Programming in Python	Lecture	m	3/4	2,5
CO17-CorePureMath	**Module: Core Pure Mathematics**		**me**		**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**7,5**
CO17-100251	Introduction to Complex Analysis	Lecture	m	3	5			Take three courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	3/4	7,5
CO17-100261	Calculus on Manifolds	Lecture	m	3	5							
CO17-100252	Introduction to Algebra	Lecture	m	4	5							
CO18-CoreAppMath	**Module: Core Applied Mathematics**		**me**		**15**							
CO18-110221	Stochastic Methods	Lecture	m	3	5		**JT-LA-Language**	**Module: Language**		**m**		**5**
CO18-110222	Stochastic Methods Lab	Lab	m	3	2,5			Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language	Seminar	me	3/4	5
CO18-110231	Applied Dynamical Systems	Lecture	m	4	5							
CO18-110233	Applied Dynamical Systems Lab	Lab	m	4	2,5							
Year 3 - CAREER					**45**							**5**
COXX	**Module: Additional (4th) CORE module**		**m**	**5/6**	**15**		**JT-TA-TriArea**	**Module: Triangle Area**		**m**		**5**
CA01-CarSkills	**Module: Career Skills**		**m**					Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS [3]		me	5	5
CA12-MATH	**Module: Project/Thesis MATH**		**m**		**15**							
CA12-100303	Project MATH		m	5	5							
CA12-100304	Thesis MATH		m	6	10							
CAS-CT-MATH	**Module: Specialization Area MATH**		**m**		**15**							
	Take **six** specialization courses (2.5 ECTS each) [2]		me	5/6	15							
Total ECTS												**180**

[1] Status (m = mandatory, e = elective, me = mandatory elective)

[2] For a full listing of all CHOICE / CORE / CAREER / Jacobs Track modules please consult the **CampusNet online catalogue** and / or the module handbook (on our website).

[3] You are required to take six Triangle Area courses in total. Select two from each of the three triangle areas (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT).

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
General Mathematics	CH07-100101	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH07-FundMath Fundamental Mathematics	125	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This course introduces fundamental concepts and techniques in a concise and rigorous way. The class conveys the pleasure of doing mathematics, motivates mathematics concepts from problems and concrete examples, but also shows the power of abstraction and of formal reasoning.
The course starts out by introducing integers, rational, and real numbers, and at the same time laying the foundation for formal proof and reasoning. Further topics include combinatorics, graphs, groups, and finally metric spaces and topology in preparation for Analysis II.

Methods of Assessment

Name	Weighting
Final Grade	100%

Course Name	***Course No***	***ECTS***
Mathematical Software Lab	CH07-100111	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH07-FundMath Fundamental Mathematics	62,5	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This course will introduce the computer as a tool for the working mathematician, as well as for scientists in many other fields. The Mathematical Software Lab introduces Mathematica, a software package that can perform complex symbolic manipulations such as solving algebraic equations, finding integrals in closed form, or factoring mathematical expressions. Mathematica also has powerful and flexible graphing capabilities that are useful for illustrating concepts as well as numerical data. The computer will be used as a tool in this course so that you will also learn some mathematics alongside learning to use the computer program.

Understand the basic concepts behind computer algebras system and how to use Mathematica to solve and present mathematical problems and their solutions.

Methods of Assessment

Name	Weighting
Final Exam	34%
Home Work	66%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Undergraduate Seminar	CH07-100122	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH07-FundMath Fundamental Mathematics	62,5	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This seminar is for all students, especially in their first year. Its goal is to develop skills in mathematical communcation: presentation, discussion, writing, and working with mathematical literature. Students give presentations, write reports on them, and discuss jointly the mathematics as well as the presentation. The topics are chosen from a wide range of mathematical areas, typically outside of the standard first-year material.

Methods of Assessment

Name	Weighting
Active Participation	10%
Papers	40%
Presentation	50%

Course Name	***Course No***	***ECTS***
Analysis II	CH07-100212	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CH07-FundMath Fundamental Mathematics	125	Bachelor 1st Year CHOICE

Course Description / Content / Aims

This course continues the introduction to mathematical Analysis from the course "Elements of Analysis" from the Jacobs Track "Methods Module". Topics include differentiation in Rn, the implicit and inverse function theorem, a brief introduction to the Riemann integral in several variables, and an introduction to differential equations with applications.

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Linear Algebra	CO16-100231	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO16-CoreMaths Core Mathematics	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course continues the introduction to Linear Algebra from the course Elements of Linear Algebra from the Jacobs track ``Methods Module''.
In the first part, we continue the discussion of endomorphisms, discussing minimal polynomials, the Cayley-Hamilton theorem, and the Jordan normal form. In particular, we study the application of the Jordan normal form to linear differential and difference equations.
The second part of the course deals with dual spaces and quadratic, symmetric and skew-symmetric forms. We introduce the dual vector space and dual linear maps and their relation with bilinear forms. Classifications are given of symmetric and skew-symmetric real bilinear forms and of Hermitian and skew-Hermitian forms over the complex numbers.

Methods of Assessment

Name	Weighting
Final Exam	100%

Course Name	***Course No***	***ECTS***
Elements of Stochastic Processes	CO16-100241	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO16-CoreMaths Core Mathematics	62,5	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course is identical to the courselet Elements of Stochastic Processes we offer as part of the Jacobs track. See Jacobs track course descriptions for details

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Introductory Real Analysis	CO16-100232	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO16-CoreMaths Core Mathematics	125	Bachelor 2nd Year CORE
Course Description / Content / Aims		
This class continues Analysis II by introducing Lebesgue integration as well as elements of Functional Analysis and Fourier methods in the concrete setting of Lebesgue spaces		

Course Name	***Course No***	***ECTS***
Numerical Methods II	CO16-100242	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO16-CoreMaths Core Mathematics JTME-MethodsMath Methods / Mathematics (for Class of 2019)	62,5	Bachelor 2nd Year CORE
Course Description / Content / Aims		
This course is identical to the courselet Numerical Methods II we offer as part of the Jacobs track. See Jacobs track course descriptions for details.		

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Introduction to Complex Analysis	CO17-100251	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO17-CorePureMath Core Pure Mathematics	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

The theory of complex-differentiable functions in one variable is a rich theory with powerful results: unlike differentiability for real functions, for example, if a function is complex differentiable, then implies that it is differentiable infinitely often and that it is represented by its Taylor series in a neighborhood of every point in its domain of definition. This results in a very nice and elegant theory that is used in many areas of mathematics.
Topics include holomorphic functions, Cauchy integral theorem and formula, Liouville's theorem, fundamental theorem of algebra, isolated singularities and Laurent series, analytic continuation and monodromy theorem, residue theorem, normal families, and the Riemann mapping theorem.

Course Name	***Course No***	***ECTS***
Calculus on Manifolds	CO17-100261	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO17-CorePureMath Core Pure Mathematics	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course is a first introduction to modern concepts in geometry and topology which are fundamental to specialization topics in Pure Mathematics.
Topics include manifolds, differential forms, and Stokes theorem (on differential forms and retranslation into its classical formulation).

Methods of Assessment

Name	Weighting
Final Grade	100%

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Introduction to Algebra	CO17-100252	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO17-CorePureMath Core Pure Mathematics	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course gives an introduction to three basic types of algebraic structures: groups, commutative rings, and fields. (If time permits, a fourth one: modules.) Here is a more detailed list of topics to be covered.
Group Theory: Definitions and key examples. Cosets and Lagrange's theorem. Group homomorphisms and basic constructions including quotient groups, direct and semi-direct products. Some examples of (important) groups. Group actions and orbit-stabilizer theorem. Possibly: Sylow theorems.
(Commutative) Rings: Definitions and elementary properties. Ideals, ring homomorphisms and quotient rings. Domains, Euclidean domains, principal ideal domains and unique factorization. Polynomial rings.
Field extensions: Roots of polynomials. Irreducibiliy criteria. Finite and algebraic field extensions. Finite fields. Possibly: Splitting fields and algebraic closure. Constructions with straightedge and compass.
If time permits Modules: Definitions and basic constructions. Linear maps and exact sequences. Direct products and sums. Structure theory for finitely generated modules over a principal ideal domain.

Course Name	***Course No***	***ECTS***
Stochastic Methods	CO18-110221	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO18-CoreAppMath Core Applied Mathematics	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course is a first hands-on introduction to stochastic modeling. Examples will mostly come from the area of Financial Mathematics, so that this course plays a central role in the education of students interested in Quantitative Finance and Mathematical Economics.
Topics include binomial tree models, discrete Brownian paths, stochastic ODEs, Monte-Carlo methods, finite differences solutions for the Black-Scholes equation, and an introduction to time series analysis, parameter estimation, and calibration. Students will program and explore all basic techniques in a numerical programming environment and apply these algorithms to real data whenever possible

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Stochastic Methods Lab	CO18-110222	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO18-CoreAppMath Core Applied Mathematics	62,5	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course is a first hands-on introduction to stochastic modeling. Examples will mostly come from the area of Financial Mathematics, so that this course plays a central role in the education of students interested in Quantitative Finance and Mathematical Economics.
Topics include binomial tree models, discrete Brownian paths, stochastic ODEs, Monte-Carlo methods, finite differences solutions for the Black-Scholes equation, and an introduction to time series analysis, parameter estimation, and calibration. Students will program and explore all basic techniques in a numerical programming environment and apply these algorithms to real data whenever possible

Course Name	***Course No***	***ECTS***
Applied Dynamical Systems	CO18-110231	5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO18-CoreAppMath Core Applied Mathematics	125	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course is a first hands-on introduction to theory and applications of dynamical systems. A crucial component of this class will be the use of computer experiments to foster intuitive understanding and develop students' skills in using the computer to bridge between mathematical idea and concrete implementation and application.
Topics include nonlinear oscillators, coupled pendula, and pattern formation in chemical reactions. A main focus of the lab is the development of standard tools for the numerical solution of differential equations, the application of automated tools for bifurcation analysis, and continuation methods. We will also implement simple agent-based models and pseudo-spectral PDE solvers for reaction-diffusion equations.

Appendix 2 - Course Data

Course Name	***Course No***	***ECTS***
Applied Dynamical Systems Lab	CO18-110233	2,5
Module Affiliation	***Workload (hrs / sem)***	***Level***
CO18-CoreAppMath Core Applied Mathematics	62,5	Bachelor 2nd Year CORE

Course Description / Content / Aims

This course is a first hands-on introduction to theory and applications of dynamical systems. A crucial component of this class will be the use of computer experiments to foster intuitive understanding and develop students' skills in using the computer to bridge between mathematical idea and concrete implementation and application.
Topics include nonlinear oscillators, coupled pendula, and pattern formation in chemical reactions. A main focus of the lab is the development of standard tools for the numerical solution of differential equations, the application of automated tools for bifurcation analysis, and continuation methods. We will also implement simple agent-based models and pseudo-spectral PDE solvers for reaction-diffusion equations.