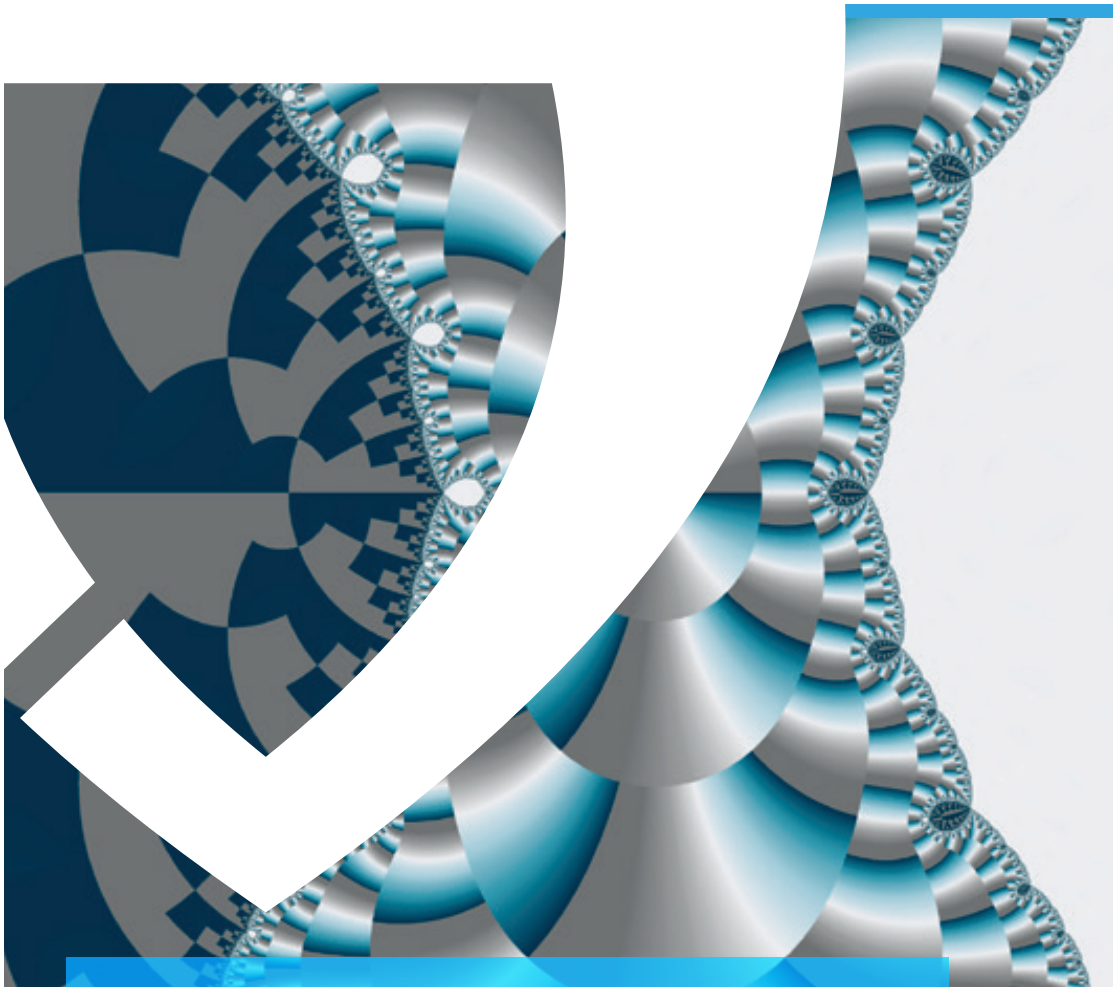




JACOBS  
UNIVERSITY



Study Program Handbook

# Mathematics

Bachelor of Science

## Contents

<b>1</b>	<b>The Mathematics Study Program</b>	<b>1</b>
1.1	Concept . . . . .	1
1.2	Specific Advantages of the Mathematics Program at Jacobs University . . . . .	1
1.3	Program-Specific Qualification Aims . . . . .	2
1.4	The Jacobs University Employability and Personal Development Concept . . . . .	2
1.5	Career Options . . . . .	3
1.6	More Information and Contact . . . . .	4
<b>2</b>	<b>The Curricular Structure</b>	<b>5</b>
2.1	General . . . . .	5
2.2	The Jacobs University 3C-Model . . . . .	5
2.2.1	YEAR 1 - CHOICE . . . . .	6
2.2.2	YEAR 2 - CORE . . . . .	6
2.2.3	YEAR 3 - CAREER . . . . .	6
2.3	The Jacobs Track . . . . .	7
2.4	Modularization of the Mathematics Program . . . . .	8
2.4.1	Content . . . . .	8
2.4.2	Structure . . . . .	10
<b>3</b>	<b>Appendix 1a/1b:</b>	
	<b>Mandatory Course Plans for World Track and Campus Track</b>	<b>11</b>

# 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 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 acquiring, understanding, and 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 academia 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](mailto:dierk@jacobs-university.de)  
Telephone: +49 421 200-3213

Dr. Marcel Oliver  
Professor of Mathematics  
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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:

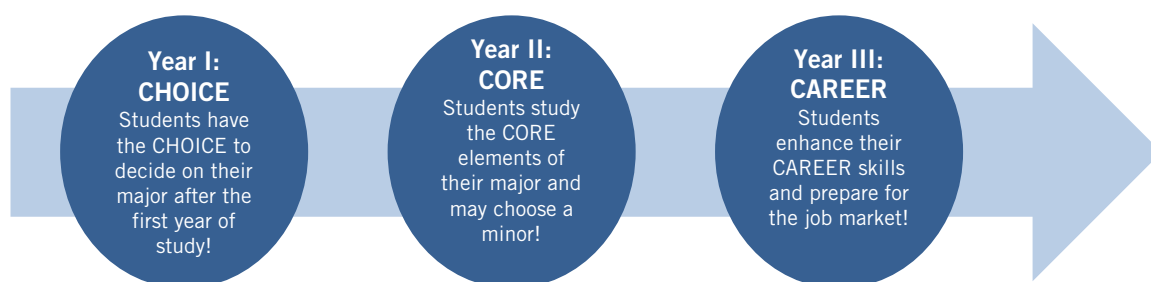


Figure 1: The Jacobs University 3C-Model

### 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 University's 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 Union's 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.

All students attend a mandatory set of career skills courses and events throughout their studies. These equip them with necessary skills for their 5th semester and their future career.

### **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

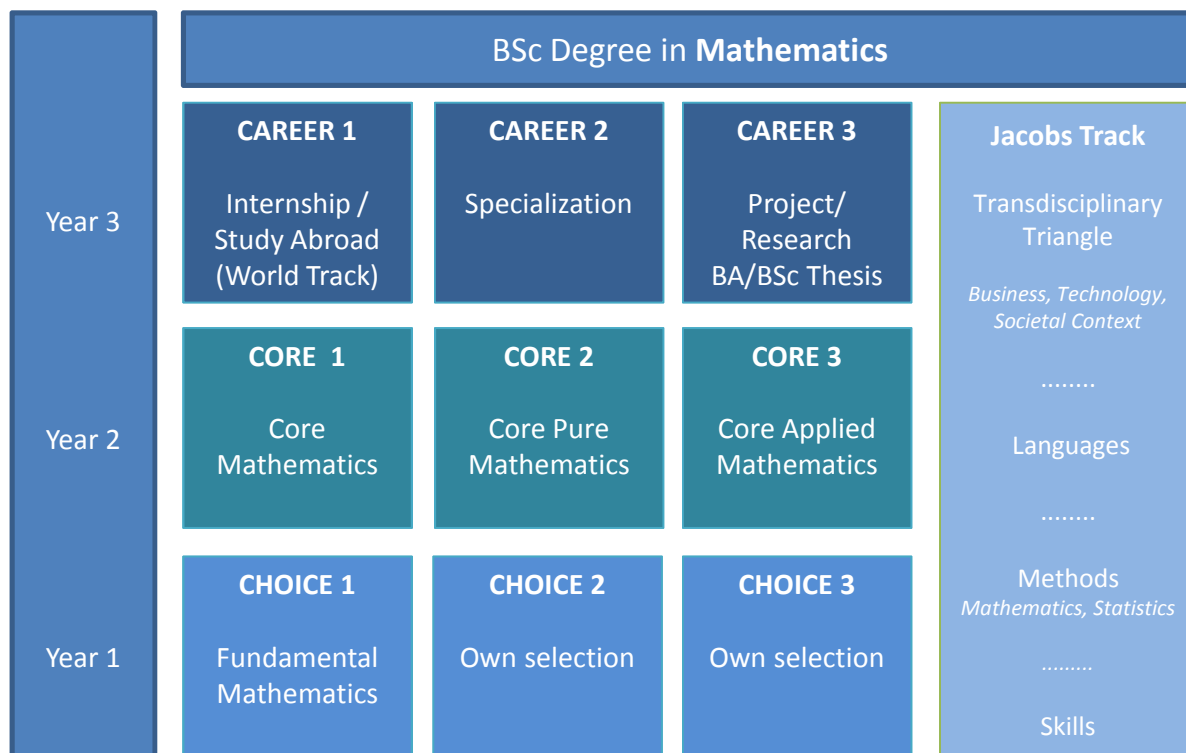
- Mathematics Project / Thesis Module
- Program-specific Specialization Module  
Exemplary course offering:
  - Algebra and Geometry
  - Manifolds and Topology
  - Number Theory
  - Discrete Structures and Optimization
  - Stochastic Processes and Finance
  - Functional Analysis and Elliptic Operators
  - Numerical Analysis and Scientific Computing
  - Mathematical Modeling with PDEs
  - Differential Equations and Dynamical Systems
  - Topics in Mathematics

**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

### 2.4.2 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 2: Mathematics Module Structure

### **3 Appendix 1a/1b: Mandatory Course 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

## Appendix 1a - Mandatory Course Plan for World Track

Mathematics – World Track												
Matriculation Fall 2015												
Program-Specific Modules					Jacobs Track Modules (General Education)							
Type	Status <sup>1</sup>	Semester	Credits		Type	Status <sup>1</sup>	Semester	Credits				
<b>Year 1 - CHOICE</b>				<b>45</b>							<b>20</b>	
<i>Take the mandatory CHOICE module listed below, this is a requirement for the Mathematics program.</i>												
<b>CH07-FundMath</b>	<b>Module: Fundamental Mathematics</b>			<b>m</b>						<b>15</b>		
CH07-100101	General Mathematics	Lecture	m	1	5	<b>JT-ME-MethodsMath</b>	<b>Module: Methods / Mathematics</b>			<b>m</b>	<b>10</b>	
CH07-100111	Mathematical Software Lab	Lab	m	1	2,5	JTME-120203	Elements of Analysis I	Lecture	m	1	2,5	
CH07-100212	Analysis II	Lecture	m	2	5	JTME-120204	Elements of Analysis II	Lecture	m	1	2,5	
CH07-100122	Undergraduate Seminar	Lab	m	2	2,5	JTME-120112	Foundations of Linear Algebra I	Lecture	m	2	2,5	
	<b>Module: CHOICE (own selection)</b>			<b>e</b>	<b>1/2</b>	<b>30</b>	JTME-120113	Foundations of Linear Algebra II	Lecture	m	2	2,5
<i>Students take two further CHOICE modules from those offered for all other study programs. <sup>2</sup></i>												
<b>Year 2 - CORE</b>				<b>45</b>							<b>20</b>	
<i>Take all three modules <u>or</u> replace one with a CORE module from a different study program. <sup>2</sup></i>												
<b>CO16-CoreMaths</b>	<b>Module: Core Mathematics</b>			<b>me</b>						<b>15</b>		
CO16-100231	Linear Algebra	Lecture	m	3	5	<b>JT-ME-MethodsMath</b>	<b>Module: Methods / Mathematics</b>			<b>m</b>	<b>5</b>	
CO16-100241	Elements of Stochastic Processes	Lecture	m	3	2,5	JTME-120201	Elements of Probability	Lecture	m	3	2,5	
CO16-100232	Introductory Real Analysis	Lecture	m	4	5	JTME-120202	Numerical Methods I	Lecture	m	4	2,5	
CO16-100242	Numerical Methods II	Lecture	m	4	2,5	<b>JT-SK-Skills</b>	<b>Module: Skills</b>			<b>m</b>	<b>2,5</b>	
<b>CO17-CorePureMath</b>	<b>Module: Core Pure Mathematics</b>			<b>me</b>						<b>15</b>		
CO17-100251	Introduction to Complex Analysis	Lecture	m	3	5	JTSK-320112/350112	Students take either Programming in C II or Advanced Programming in Python	Lecture	m	3/4	2,5	
CO17-100261	Calculus on Manifolds	Lecture	m	3	5	<b>JT-TA-TriArea</b>	<b>Module: Triangle Area</b>			<b>m</b>	<b>7,5</b>	
CO17-100252	Introduction to Algebra	Lecture	m	4	5		Take three courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS <sup>3</sup>	me	3/4	7,5		
<b>CO18-CoreAppMath</b>	<b>Module: Core Applied Mathematics</b>			<b>me</b>						<b>15</b>		
CO18-110221	Stochastic Methods	Lecture	m	3	5	<b>JT-LA-Language</b>	<b>Module: Language</b>			<b>m</b>	<b>5</b>	
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							
<b>Year 3 - CAREER</b>				<b>45</b>							<b>5</b>	
<b>CA02 / CA03</b>	<b>Module: Internship / Study Abroad</b>			<b>m</b>	<b>5</b>	<b>20</b>	<b>JT-TA-TriArea</b>	<b>Module: Triangle Area</b>			<b>m</b>	<b>5</b>
<b>CA01-CarSkills</b>	<b>Module: Career Skills</b>			<b>m</b>				me	6	5		
<b>CA12-MATH</b>	<b>Module: Project/Thesis MATH</b>			<b>m</b>		<b>15</b>						
CA12-100303	Project MATH		m	6	5							
CA12-100304	Thesis MATH		m	6	10							
<b>CA-S-MATH</b>	<b>Module: Specialization Area MATH</b>			<b>m</b>		<b>10</b>						
	Take four specialization courses (2,5 ECTS each) <sup>2</sup>			<b>me</b>	<b>5/6</b>	<b>10</b>						
<b>Total ECTS</b>										<b>180</b>		

<sup>1</sup> Status (m = mandatory, e = elective, me = mandatory elective)

<sup>2</sup> 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).

<sup>3</sup> 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 Course Plan for Campus Track

Mathematics – Campus Track													
Matriculation Fall 2015													
Program-Specific Modules					Jacobs Track Modules (General Education)								
Type	Status <sup>1</sup>	Semester	Credits		Type	Status <sup>1</sup>	Semester	Credits					
<b>Year 1 - CHOICE</b>				<b>45</b>							<b>20</b>		
<i>Take the mandatory CHOICE module listed below, this is a requirement for the Mathematics program.</i>													
<b>CH07-FundMath</b>	<b>Module: Fundamental Mathematics</b>			<b>m</b>						<b>15</b>			
CH07-100101	General Mathematics	Lecture	m	1	5	<b>JT-ME-MethodsMath</b>	<b>Module: Methods / Mathematics</b>			<b>m</b>	<b>10</b>		
CH07-100111	Mathematical Software Lab	Lab	m	1	2,5	JTME-120203	Elements of Analysis I	Lecture	m	1	2,5		
CH07-100212	Analysis II	Lecture	m	2	5	JTME-120204	Elements of Analysis II	Lecture	m	1	2,5		
CH07-100122	Undergraduate Seminar	Lab	m	2	2,5	JTME-120112	Foundations of Linear Algebra I	Lecture	m	2	2,5		
	<b>Module: CHOICE (own selection)</b>			<b>e</b>	<b>1/2</b>	<b>30</b>	JTME-120113	Foundations of Linear Algebra II	Lecture	m	2	2,5	
<i>Students take two further CHOICE modules from those offered for all other study programs. <sup>2</sup></i>													
<b>Year 2 - CORE</b>				<b>45</b>							<b>20</b>		
<i>Take all three modules <u>or</u> replace one with a CORE module from a different study program. <sup>2</sup></i>													
<b>CO16-CoreMaths</b>	<b>Module: Core Mathematics</b>			<b>me</b>						<b>15</b>			
CO16-100231	Linear Algebra	Lecture	m	3	5	<b>JT-ME-MethodsMath</b>	<b>Module: Methods / Mathematics</b>			<b>m</b>	<b>5</b>		
CO16-100241	Elements of Stochastic Processes	Lecture	m	3	2,5	JTME-120201	Elements of Probability	Lecture	m	3	2,5		
CO16-100232	Introductory Real Analysis	Lecture	m	4	5	JTME-120202	Numerical Methods I	Lecture	m	4	2,5		
CO16-100242	Numerical Methods II	Lecture	m	4	2,5	<b>JT-SK-Skills</b>	<b>Module: Skills</b>			<b>m</b>	<b>2,5</b>		
	<b>Module: Core Pure Mathematics</b>			<b>me</b>			JTSK-320112/350112	Students take either Programming in C II or Advanced Programming in Python	Lecture	m	3/4	2,5	
CO17-100251	Introduction to Complex Analysis	Lecture	m	3	5	<b>JT-TA-TriArea</b>	<b>Module: Triangle Area</b>			<b>m</b>	<b>7,5</b>		
CO17-100261	Calculus on Manifolds	Lecture	m	3	5		Take three courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS <sup>3</sup>			<b>me</b>	<b>3/4</b>	<b>7,5</b>	
CO17-100252	Introduction to Algebra	Lecture	m	4	5	<b>JT-LA-Language</b>	<b>Module: Language</b>			<b>m</b>	<b>5</b>		
	<b>Module: Core Applied Mathematics</b>			<b>me</b>				Take two German courses (2,5 ECTS each). Native German speakers take courses in another offered language			<b>me</b>	<b>3/4</b>	<b>5</b>
CO18-110221	Stochastic Methods	Lecture	m	3	5	<b>Year 3 - CAREER</b>					<b>5</b>		
CO18-110222	Stochastic Methods Lab	Lab	m	3	2,5	<b>COXX</b>	<b>Module: Additional (4th) CORE module</b>			<b>m</b>	<b>5/6</b>	<b>15</b>	
CO18-110231	Applied Dynamical Systems	Lecture	m	4	5	<b>CA01-CarSkills</b>	<b>Module: Career Skills</b>			<b>m</b>			
CO18-110233	Applied Dynamical Systems Lab	Lab	m	4	2,5	<b>CA12-MATH</b>	<b>Module: Project/Thesis MATH</b>			<b>m</b>	<b>15</b>		
	<b>Module: Specialization Area MATH</b>			<b>m</b>			Take two courses from the triangle (BUSINESS, TECHNOLOGY & INNOVATION, SOCIETAL CONTEXT) area. Each counts 2,5 ECTS <sup>3</sup>			<b>me</b>	<b>5</b>	<b>5</b>	
	Take six specialization courses (2.5 ECTS each) <sup>2</sup>			<b>me</b>	<b>5/6</b>	<b>15</b>	<b>Total ECTS</b>				<b>180</b>		

<sup>1</sup> Status (m = mandatory, e = elective, me = mandatory elective)

<sup>2</sup> 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).

<sup>3</sup> 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).